

ARTIFICIAL PNEUMOTHORAX.

A CRITICAL REVIEW OF THE INDICATIONS FOR AND

RESULTS OF TREATMENT.

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by

ARTHUR BLOOM, M.C., M.B.Ch.B. 1911.

Physician to the Johannesburg Hospital.

Lecturer in Clinical Medicine to the University
of Witwatersrand.

Consulting Physician to the Springkell Sanatorium,
Johannesburg.

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Introduction.

Lung collapse, first advocated more than a century and a half ago, is now firmly established as a valuable measure in the treatment of pulmonary disease.

The main object of this investigation has been to attempt to assess the value of artificial pneumothorax treatment and to study the effects of collapse therapy in a number of cases in which this treatment has been carried out.

The last twenty years or so, have seen artificial pneumothorax therapy emerge from the purely experimental stage and now it has gained a world wide recognition as a most important method of treatment in pulmonary disease.

In the series of twenty-five cases which form the basis of this study and of which particulars will be given later, the treatment was instituted only when dietetic, medicinal and others measures had been tried without avail and in the majority of cases when the progress of the disease had been considerable.

A comparison of the results obtained in this series of cases tends to show that provided the

disease is not too far advanced and that the case is an otherwise suitable one, arrest of the disease for considerable periods can be obtained, and that in a great majority of the cases, the treatment has the effect of diminishing the symptoms, lessening the toxæmia and promoting such a feeling of well-being that the patient so treated is enabled to live an ordinary life and to follow his usual occupation and can earn his own living when this is necessary.

Moreover, striking improvement may be seen occasionally in the otherwise "hopeless" case. There appears to be no doubt that artificial pneumothorax treatment holds a distinct place in the palliation of the far advanced case:- even when the collapse produced is quite small, perhaps only a few hundred cubic centimetres. It may be sufficient to convert a burdensome life into a comparatively comfortable one.

What constitutes a "suitable case" for the treatment must be largely a question for the physician concerned - and as is only natural, the personal factor tends to play no inconsiderable part in the selection of "suitable" cases for treatment.

In most cases of Pulmonary Tuberculosis of the

progressive type, there seems to be no doubt that a time may come sooner or later in the course of the disease when an artificial pneumothorax is indicated.

In a condition where the sequelae may be fraught with such distress to the patient as in pulmonary tuberculosis, it is gratifying to find some therapeutic measure which, if successful will ameliorate the patient's lot considerably .

Details and actual figures will be dealt with later but for the present it will suffice to say that in a small percentage of the cases in the series studied, the artificial pneumothorax did not produce a favourable result but was only just sufficient to control the disease. These patients are therefore not able to lead active useful lives but are more or less invalids and the eventual outlook for them is not so promising.

In only one case was the induction and continuance of the pneumothorax a factor in hastening a fatal termination, in all the other cases, relief from distressing symptoms soon occurred, the establishment of even a partial collapse tending in every case to give comfort in the last few months of life to those otherwise doomed to pain and dis-

comfort.

It might be thought at first glance that this series of cases had been specially picked out to show successful results. This is not so, they are the total number of consecutive cases that have completed treatment up to 1930.

The notes of these cases are included in a later section of the thesis and although all the data are not given for the sake of brevity yet in every case a record has been kept of the details in regard to intra-thoracic pressures, amounts injected, variations in the patient's weight, the symptoms, alteration in the physical signs, radiographic reports, sputum reports, etc., from the time the patient came under observation until the termination of treatment. These reports necessarily vary in length depending upon the time the patient has been under observation and the essential parts of each report are appended in a later section with charts and radiographs.

To my mind, three very important factors make for success in artificial pneumothorax treatment.

- (a) The ability of the physician to decide upon the suitability of the particular case.
- (b) The proper management of the case after the artificial pneumothorax has been induced - and last but by no means least.....

(c) The intelligent co-operation of the patient.

The last is of great importance. Such experience as the author has gained in artificial pneumothorax therapy has shown that it is the painstaking, steady, intelligent patient who does well and that it is not a procedure to be advised to those of careless habits and thoughtless disposition.

Artificial pneumothorax treatment was introduced to London whilst I was working there on Tuberculosis in 1912-1914; but the type of case chosen was, through lack of experience, mostly unsuitable and the results were, in many cases, disastrous.

The technique, even then, was cumbersome. Pioneers, however, realised the possibilities of this treatment, and in 1921, when I had occasion again to attempt collapse therapy, in South Africa one found there was an excellent technique laid down and also a literature which strongly advocated its use; since then, I have used it as an aid to other methods of treatment.

It is an excellent addition to the armamentarium of a physician. It has its limitations, and exacts a severe penalty if these are not obeyed.

I have attempted to set out what these limits are,

illustrated by a series of cases occurring in my practice in S. Africa.

South African conditions differ, somewhat, from European and British in that, for the whole of our white population which totals a million and a half, we only have one Sanatorium. It is always full, and there is a long waiting list. The result is, that cases which normally would be eminently suitable for sanatorium treatment either have to lie up at home, or else have to come in to the General Hospital of Johannesburg.

The majority of my cases were treated in the Johannesburg General Hospital where we have open air verandahs, giving ideal conditions. It might be asked why these cases were not treated by rest in the country in a climate which is so eminently suitable. Granted that we have large areas of country which are high, dry and free from dust yet those of us who have to treat tuberculosis realise that there are many factors to be considered other than climatic conditions.

Rest and open air is a suitable method of treatment for those patients who have had a previous education in a sanatorium, but it is of no use for

the uneducated patient. For these reasons, the vast majority of my series, as I have said, have been treated in hospital, where the cases have had skilled nursing treatment, and where their progress has been carefully watched both clinically and by X-ray examinations.

After their discharge from hospital a certain number have been able to go to the sanatorium for a few months; but except for these short periods of absence, they have all been dealt with by me from the beginning of their treatment until its cessation. Those that have completed their treatment come up for periodical examinations at regular intervals.

As will be seen, they were kept in hospital for varying periods but the majority had long stays. The extent of the artificial pneumothorax, was carefully observed by regular screening - an essential part of the technique unobtainable at our only sanatorium.

Although the vast majority of artificial pneumothorax inductions were done for tuberculosis disease, two were done in an attempt to treat abscess of the lung.

In all the cases (except one) a unilateral

pneumothorax was induced. The exception was a case of bilateral tuberculous bronchopneumonia, in which a simultaneous partial collapse of both lungs was produced. (Case 17 in the list).

The History of Artificial Pneumothorax.

In England the early history of artificial pneumothorax dates back to the year 1821 when Dr. James Carson of Liverpool in a series of clear and well reasoned physiological essays advanced pulmonary collapse as a means of treating lesions of the lungs.

These essays were read before the Literary and Philosophical Society of Liverpool and demonstrated in the most lucid and practical manner the advantages of collapsing the lung in the treatment of disease. In setting forth the basic principles of collapse therapy and in evolving theories which have served to guide all later investigators, Carson undoubtedly proved himself to be a pioneer of exceptional ability.

It is not only noteworthy but remarkable that his ideas and the principles of treatment advocated by him and supported by animal experiments are in accordance with the basic principles of artificial pneumothorax treatment in vogue today and the clarity of his reasoning has stood the test of over a century of time. His experiments were instituted to supply a surer and more ample foundation for the observations

he made respecting the peculiar character of lesions of the lungs and the course which he thought should be observed in attempts to cure or alleviate such disease.

He advocated pulmonary collapse as the method of choice in the treatment of lung abscess, in severe and intractable haemoptysis and in unilateral pulmonary tuberculosis. He even foresaw the possibilities of alternating collapse in treating bilateral tuberculosis.

In regard to technique his advice appeared to be equally sound - he advised that the "lung should be reduced to a state of collapse by degrees only". This he said "might be accomplished by admitting a small quantity of air into the cavity of the chest at one time, and allowing an interval to elapse between the successive admissions, which may be necessary before the lung shall be brought to a state of complete collapse". In speaking of lung abscess, he demonstrated conclusively that the greatest impediment to the healing of such a lesion was the elasticity of the lung tissue and the constant movement of the lungs in the process of respiration. He draws attention to the fact that

to expect healing to occur in a lesion of this nature would be as unlikely as to expect union in a divided Tendo Achilles without mechanical aid, for he says, "it has been proved that the substance of the lungs is powerfully elastic, and that in the living system it is at all times on the stretch. When a lesion from any cause occurs in the lungs, the sides of the divided substance recede in opposite directions and a power equal to the elastic spring of the fibres tends, not only to prevent the approach of the divided parts but still further to increase the breach".

In 1837, Stokes (Stokes - A treatise on the diagnosis and treatment of Diseases of the Chest - 1837) recognised that the change for the better in Pulmonary tuberculosis in which a spontaneous pneumothorax had occurred was due to the compression of the affected lung.

It appears that Stokes realised that certain cases of spontaneous pneumothorax got better but others did not benefit.

Douglas Powell in 1869 recognised that the reasons for many of the failures was, inter alia, the amount of disease of the other lung and he advised artificial collapse and advocated the measure-

ment of the gas.

Nothing radical appears to have been done until Forlanini, who had already in 1882 published a paper on the subject, in 1906 published further cases. He gave very high doses of nitrogen without measuring the amount. For a long time he refused to use a manometer. It sounds a dangerous proceeding and must have been responsible for such accidents as gas embolism and pleural shock, dangers that are never met with nowadays.

In the Lancet, Vol.1, 1882 a method of tapping an empyema and the replacement of carbolised air was described by Douglas Powell.

In 1885 Cayley (in a paper read before the Middlesex Hospital) described a case of haemoptysis treated by the induction of pneumothorax but the patient died soon afterwards from generalised tuberculosis.

Potain about this time also was doing what is now called an air replacement of air effusion with successful results. He used a manometer to estimate the pressures but no detailed description of the apparatus seems to have been given.

The next step forward was by Murphy who with a

trocac and cannula injected air into the pleural space and stimulated one of his assistants Lemke to also use this treatment in fifty three cases, but the results were not given.

According to Lemke (Quarterly Journal of Medicine, Vol. VI, 1912-1913) this work however had the effect of stimulating Brauer (a professor at Marburg) to interest himself and his work and technique was a great advance on anything which had been done previously. He was the first to use a manometer while gas was being injected and he could accurately measure the intra-pleural pressures. Artificial pneumothorax gradually became a safe and sound procedure and about 1910-1911 began to be recognised as of value in the treatment of Pulmonary Tuberculosis.

Lillingstone himself a sufferer and a patient introduced the method to this country in the Practitioner 1913, and describes the effect of collapse therapy on himself and he makes a very significant statement when he says that it is essential in gauging the value of any treatment to test it by the results in a large number of cases.

The writer himself had the opportunity in 1912 of watching the earlier workers and seeing their

technique and the class of case selected for this treatment. Unfortunately at that time the results were poor. It is easy to realise now that many of these cases were most unsuitable and in the light of present day knowledge artificial pneumothorax should not even have been attempted. Happily as experience has been gained and results of treatment of suitable cases published, it is now more easily known what cases will do well. Refinements of operative technique have gradually been introduced and today the pain and discomfort are negligible and the manipulative skill required is small.

The proper selection of cases is, however, not yet sufficiently widely known. For this reason there is a danger of unsuitable cases being selected on the one hand and on the other hand many suitable cases are constantly being passed over.

Indications for Artificial Pneumothorax.

Suitable selection of cases for artificial pneumo-thorax is the main condition of success. It is essentially an aid to other methods of treatment, and therefore, broadly speaking, cases are chosen that are progressing unfavourably under the best conditions available. The treatment is only possible in a certain number of cases. It has been said that every case, at one time or another, has passed through a stage of the disease which would have been a suitable one for pneumo-thorax treatment. This is true of a certain number of advanced cases that are seen, but others are bilateral from the start, and at no time have they ever been likely types for this treatment. The percentage of cases that are suitable for pneumo-thorax treatment varies considerably in reported statistics which give anything from 2% to 20%. All are agreed that it is most important not to allow cases to progress beyond the stage of disease at which collapse therapy and every other method of treatment becomes too late. It is also agreed that the most suitable case for artificial pneumo-thorax is one of severe one-sided disease with the contra-

lateral lung clear, and most benefit is seen in this type of case. Cavitation in this group is not considered a bar to this form of treatment if complete collapse is obtained. Where adhesions permit only of a partial collapse, the results are not so beneficial.

Considerable use of the X-Ray is made in determining whether the contra-lateral lung is affected, and many reporters seem to use the X-Ray to define the condition of the other lung paying little attention to clinical evidence. They suggest that often the disease is deep-seated, and cannot be recognised by ordinary clinical methods. Views as to whether this method of treatment should be used in early cases or not, differ. The advocates of the early treatment put forward the view that patients are in a better state to stand the treatment, the need for a shorter time of collapse, and the greater possibilities of complete collapse before cavitation and possible adhesions prevent this happening. It is agreed that pleural adhesions are the commonest cause, either entirely preventing collapse, or only allowing a limited pneumo-thorax to occur, and therefore by doing the

unilateral case early, it is unlikely that adhesions will have grown. There is, however, another attitude taken about early cases. It is realised that a number of these cases are curable by other methods; that there is a certain amount of risk attached to the treatment, such as pleural shock, and gas embolism. Pleural effusion and deformity of the lung may follow. Pleural adhesions, following its re-expansion, may prevent a re-collapse at a later date if required. These are the main objections to early treatment. Beaumont classifies his cases in terms of unilateral disease and temperature.

(1) Cases were suitable for this in which the disease was unilateral, and the patients failed to respond to absolute rest in bed for a month.

(2) The same type as (1), but which did respond but on getting up again became pyrexial.

(3) Recurrent haemoptysis not yielding to ordinary measures.

Burrell recommends artificial pneumothorax in "any case that shows activity after six months medical treatment".

Haemoptysis. The consensus of opinion is that, if possible, a pneumo-thorax should be induced where

haemorrhage is profuse, and recurrent. Even if both lungs are affected. The difficulty, very often, is to locate the side of the haemorrhage, and usually, the presence of adhesions, prevent the entry of air into the pleural cavity.

Tuberculous empyema. The results of tapping off the pus in these cases, and replacing it by air, is a recognised method of treatment, and in a certain number of cases good results have been obtained. The majority of these cases of purulent effusions do not respond to the introduction of air, and as a rule, go on finally to a surgeon for thoracoplasty, and good results are claimed.

Serous effusions. The biggest claim for artificial pneumo-thorax by enthusiasts is that if the fluid absorbs naturally in these cases, the inflamed surfaces, once allowed to come together, become densely adherent, and prevent collapse at some future date.

Laryngeal tuberculosis. Is recognised as one of the complications that does well under artificial pneumo-thorax. These excellent results are due to a diminution of the toxæmia, decrease of cough, and reduction in the quantity of sputum.

In cases of bilateral disease it is most important to determine whether the better lung is going to stand up to the treatment. A large amount of strain is going to be put on it and no effort should be spared to determine its efficiency. Constant clinical examination from day to day is necessary to see if, while the patient is at complete rest, any alterations occur in the percussion note or auscultatory findings. X-Ray examination is a useful aid, but too much reliance should not be placed on one method alone. The amount of systemic disturbance is carefully considered, and this is the most important method of deciding whether a collapse treatment is to be done. Constant observation will give one a very good idea as to whether the toxaemia is coming from one lung or both. The greater the toxaemia from the worse diseased lung, the greater the likelihood that a good result will be obtained. The diminution of the general intoxication will produce a healing of the better lung in spite of the greater effort that is put upon it. A good deal more after-care has to be taken to prevent any undue strain on the better lung. A prolonged and complete rest in

spite of a diminished or absent toxaemia should be ordered, and the effect of the slightest effort must be carefully observed. If this is done, a number of cases will give good results that would not, at first sight, appear to have been suitable. As one's experience of these cases which are of doubtful suitability increases, so it is possible, with fair accuracy, to decide those that can be done with success, and those which will have only disastrous results.

Contra-indications.

Contra-indications may be divided into those:-

- (1) Due to the disease.
- (2) Due to the general condition of health.

Unilateral collapse of the lung is contra-indicated in extensive bi-lateral disease; in a few cases very carefully and specially selected it may be possible to produce a unilateral pneumo-thorax which will, at its best, have the effect of prolonging life for a variable time.

Opinion is still divided as to the stage of the disease in which the induction of an artificial pneumo-thorax should be performed, and today the treatment tends to be instituted at an earlier stage than formerly.

Riviere has stated that "a disqualification more important in his opinion than that afforded by bi-lateral disease exists in the instance of early phthisis".

The application of collapse therapy to these cases can for various reasons be shown to be contra-indicated. It is in the first place unnecessary since in the early stages it is a disease readily curable by other methods and in the second place

artificial pneumothorax is not a treatment to be lightly undertaken. The risks are small with modern technique but it is a very long and tedious treatment and should not be undertaken unless the case is failing to progress under the best available conditions and treatment.

Tubercle bacilli. A very definite contra-indication is the failure to find tubercle bacilli in the sputum after repeated examinations.

Asthma and bronchitis. Such conditions of the Respiratory system as asthma, chronic bronchitis and emphysema with the associated anorexia are not suitable.

In many debilitating diseases where pulmonary tuberculosis is really only a manifestation of the end result of the original disease.

Chronic cardio vascular disease such as nephritis and similar conditions.

Age. It is said that anyone over the age of 60 years is unsuitable and although I have no experience of this treatment, it seems that a child of tender years would be a very difficult patient.

Tubercular diathesis in view of my experience with one of my cases, a bad family history would be

considered as a possible contra-indication.

Mentally unstable cases and those whose temperamentally are unsuited to undergo a prolonged course of treatment.

Young, Lancet, March 22/24, page 583, puts localised, acute, tuberculous pneumonia or broncho pneumonia as a contra-indication. This is, however, not my experience, as if the disease is unilateral they have done well.

Rationale of the treatment.

Artificial pneumothorax aims at allowing complete rest of the lung by means of its collapse. Carson pointed out how the constant movements, condition of extension and the elasticity prevented healing in pulmonary tuberculosis. The lung in artificial pneumothorax collapses by its own elasticity, this being no longer controlled by the intrapleural pressure. When this elastic recoil is complete, the pressure of the pleural space will be approximately atmospheric. The object of collapse treatment is to get the lung collapsed by its own elasticity and not by high pressures, as this will produce the same symptoms that are to be seen in cases of spontaneous pneumothorax. The aim then is to allow collapse of the lung aided by optimum doses of air rather than to give maximum or overdoses of air and force the collapse of the lung.

Effect of Lung Collapse.

The outstanding effect is the reduction of the toxæmia and this begins to take place in many cases even before the lung is collapsed.

According to Gardner (Amer. Review of Tubercul-

osis, 1924-1925, X, 501) the lymph channels are all obliterated by pressure in the hilus region of the lung but dilated at the periphery and it is in this way that absorption of toxins is diminished. The blood supply is also affected and toxic products are not disseminated. This is the first action of rest; later fibrosis occurs round the tubercles limiting the out-put of toxins and actually cutting off the blood supply by contraction of the scar tissue and finally there is the specific action that rest has on limiting the activity of the tubercle bacillus - preventing the manufacture in excess of auto toxin. Just as much as an optimum dose of tuberculin will produce a healing effect in a suitable case of tuberculosis, so also will an overdose produce an excessive focal and general reaction. There is an increase of blood to the various local lesions and a spate of toxins and broken down bacilli are carried to all areas, activating them and producing physical signs at these local sites. In other words, a focal reaction occurs - a general reaction is also produced with marked increase of the systemic disturbance.

The manufacture of these toxins ceases, due

primarily to the rest, and healing not only of the main focus occurs, but flooding of the subsidiary parts by toxins is also stopped, and these small outlying areas rapidly begin to fibrose.

Rest is important in the treatment of suppurating lesions of the lung, but the main method of attack, in these cases, must be to open and evacuate the pus.

The more complete the rest the better, as is seen in cases of bilateral collapse, where the rest obtained is incomplete. The toxaemia is diminished but not completely abolished.

Technique.

Apparatus Required.

The books published on this subject (vide Bibliography) give a very excellent account of the technique for inducing artificial pneumothorax, and it is unnecessary here to go into the full details of the apparatus and the methods. I propose only to deal with some modifications which have been used by me and have given good results in my hands.

There are many different kinds of apparatus in use designed to induce artificial pneumothorax. The simplest is Lillingstone and Pearson's. It can be obtained at any surgical instrument makers, and is the one that I have always employed. It has the advantage that air may be inserted and also removed if necessary in cases of spontaneous pneumothorax. The needle for the primary induction is Riviere's. It has a blunt end when the trocar is removed and it is not easy to injure the visceral pleura, or enter the lung with it. The Saugman needle is used for refills, as it is sharp, pointed and does not tear the tissues. After the initial induction there is no danger of injuring the visceral pleura. The apparatus is cheap, simple to use, easily replaced

if breakages occur, and can be cleaned quite quickly. It is important to see that no leak occurs before using the apparatus.

Choice of Gas.

I have always used air for ordinary pneumothorax treatment, and have never had any trouble with it. It has all the advantages, and none of the disadvantages of either oxygen, or nitrogen. Oxygen has been used in initial inductions as it is supposed to be less liable to produce gas embolism. As this is an accident that is only due to carelessness, the choice of oxygen does not help. There is a very rapid diffusibility of gases in the pleural space and even if pure nitrogen is used within 48 hours the analysis is the same as if air had been induced.

Preparation of the Patient.

The mental attitude of the patient differs. It is quite easy if there are other cases in the ward who discuss the treatment with them, and laugh at their fears. Usually they have been in hospital sufficiently long to see the older cases immediately after the refill and quickly recognise that the treatment is simple and painless. It is rather more difficult with private patients, but the nervousness

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is largely the fear of the unknown, and after the primary induction there is no further trouble. It is necessary to explain carefully the technique, and gain both their interest and confidence. The patient is always in bed. About twenty minutes beforehand is given one sixth to one quarter of a grain of morphia - not on account of the pain but to relieve nervousness and anxiety. It frequently makes them very sick and nowadays, if possible, I omit its use. The patient is turned on to the good side with a pillow or two under the flank, with the arm of the affected side above the head, holding on to the bed-post. This separates the ribs, and widens the intercostal spaces. The area selected should be carefully cleaned with spirit in preference to iodine which, if used repeatedly, causes irritation and then a 5 cc. syringe is filled with a 2% novocaine solution with a little adrenalin added - attach a fine hypodermic needle to the syringe and introduce it intradermally inject a drop or two of the adrenalin and see that a bleb is made into the layers of the skin. Gradually push on, injecting a little novocaine all the way. As one gets near the parietal pleura make sure that the anaesthesia is good, and finally

at the pleura itself, inject a good dose. About 3 cc. of the solution in all are used, and I have had no symptoms of cocainism. The careful and exact anaesthesia of the skin and also of the pleura are most important. The needle which had been previously sterilised and then put in absolute alcohol is shaken and dried in a spirit flame. Make sure that it is not blocked, attach it to the apparatus, and then carefully insert it into the skin. The skin is often tough, and care should be exercised as it is possible to use such force that the needle may suddenly go through the skin and tissues into the lung. If the skin is very resistant, a semi-corkscrew action will help to get it through without using force. When one has got through to the muscles the trocar is removed, and the blunt cannula is gently pushed on and can be felt to snap through the pleura. If there are no adhesions at the site of puncture, an immediate manometric response is observed. The negative pressure rises, and is often quite marked, being from 3 to 10 c.mm. If there is no response, make sure that the needle is not blocked with blood clot by pushing in a stilette. The failure of response may be due to the visceral pleura coming in contact with the end

of the cannula, or it may be that one has gone too far, and is in the lung. If the failure of response is due to the visceral pleura let in a few cc.s of air, and the manometer will register the correct pressure. If the parietal pleura is not penetrated, there will be a slight oscillation, but only a small excursion. If the needle has gone into the lung there will be an oscillation, but this is very small, and not at all like the manometric movements that are observed when the needle is in the correct place. The snap of the pleura is always most distinctive and if no manometric response is to be seen after this snap, it is almost certain that one is dealing with an adherent pleura. It is not advisable to make more than one or two attempts at one sitting, as the patient not only becomes nervous, but there is a chance that one may have punctured the lung in a previous attempt and complications may follow the introduction of air. It may be said that if one fails after two or three attempts to produce an artificial pneumothorax, it is very unlikely that one will ever succeed, but on one occasion after fifteen efforts a very small partial collapse was obtained.

The Pressure.

The amount of pressure to be used depends on whether there are any adhesions present preventing a complete collapse, and one may try to give very high pressures in these cases. In two cases under my care up to 20 ccs. water was given. This is, however, most unusual, and at first one is usually able to keep the lung collapsed with a negative pressure; as a rule slightly higher pressures become necessary after the treatment has been instituted for some time. The smaller the pressure the better - especially at first; it is unwise to give high pressures of air, as the mediastinum may be displaced, and will make the patient feel very ill; it is said that it promotes pleural effusion, but that is doubtful. It does seem necessary to let the air in slowly, as a rapid influx of air may be the cause of the effusion. There is, however, no need to warm the air as some operators do.

Refills.

The success of collapse therapy depends largely on the amount of air introduced, and the frequency of its introduction. It is a long treatment, and

the patient must be impressed with the need of regular refillings. The amount introduced by me at the first operation is never over 400 cc. At first bigger amounts were given, but the reactions were often severe whereas with small doses of air no trouble is met with.

The amount of air is increased by 50 ccs. to 100 ccs. at each refill until an optimum amount is reached. The figure may vary from 500 ccs. to 12,00 ccs. The amount is arrived at by watching the pressure at the refills and also by observing the amount of collapse at X-ray screening, and also by the sensations of the patient. The experienced patient knows when he is beginning to feel "tight". Females take a good deal less air than males as a general rule. Adhesions will usually limit the amount, and so will an anchored mediastinum. The mediastinum as a rule tends to be pushed or bowed towards the contra-lateral side. It is not of very much importance and produces few or no symptoms unless there is a marked displacement, and then as can be well understood, the lung is also pushed away and does not collapse. As time goes on the mediastinum tends to get fixed or anchored and this trouble

passes off.

The spacing of the refills will differ in different cases, but a good working rule is to miss a day at each refill, that is, do the first refill on the third day, the second refill on the fourth day following that, thus:-

	<u>Amount of Air.</u>	<u>Date.</u>
Induction.	300 ccs.	6th.
1st refill.	350 ccs.	8th.
2nd refill.	400 ccs.	11th.
3rd refill.	450 ccs.	15th.
4th refill.	550 ccs.	20th.

The spacing of the refills, once the lung is completely collapsed depends on the feelings of the patient who can tell, very often, that he needs one. It is also judged by X-ray screening; the average space is about three weeks, and when in doubt, it is better to give a small amount more frequently than to allow long intervals to elapse.

Complications.

The commonest complication is surgical emphysema, and usually this is the fault of the operator. As a rule it is limited to the thorax and does not

cause any trouble, but it is most alarming if it spreads up into the neck, especially if there is pain, dyspnoea, and a choking sensation. It may arise in two ways either as a leak into the superficial tissues from the puncture site, or else it may track along a false passage between the pleural space following an attempt to collapse an adherent lung. This latter event has only once occurred to me, but the leak from the puncture site can usually be obviated by not going in directly with one's needle, but making a step-ladder puncture through the different planes of tissue. This is important if one has to give high pressures. It is a good idea to massage the puncture site gently after withdrawal of the needle, although no dressing is required nor is it of any use. Surgical emphysema is harmless but is a source of alarm and discomfort to the patient.

Pleural Effusion.

Pleural effusion is the next commonest complication that occurs. The amount varies from a small quantity of fluid that is only to be seen by means of the X-ray as a pool at the costo-phrenic angle to an amount that fills the whole of the pleural space. Various explanations have been given to account for

the frequency of pleural effusion. It is impossible to decide what is the responsible factor. Air is a foreign body, and produces irritation, and this is the most likely cause. It may come on with a temperature, malaise, and other symptoms of an infection, or with no symptoms at all, and either be noticed because of the difficulty of getting air in, or fluid may block the needle. The first knowledge of it is frequently at the periodical X-ray examination. Whether it is tuberculous in character or not, seems to me to depend on whether it occurs early in the disease or late. Since reading Burrell's views (Recent Advances in Pulmonary Tuberculosis, 1929, page 191), on pleural effusions who states that these are in all cases of tubercular origin, I have had a small number of the late effusions tested for tuberculosis by guinea-pig inoculations, and they have all been negative. This does not necessarily mean that they are not tuberculous in character, although it rather suggests that they are due to simple, chronic irritation. In the cases where serous fluid develops in the early states of the treatment, say within the first six months, it is always tuberculous in character. As long as these

effusions do not become purulent no harm will result. The treatment of these serous effusions depends on several factors, and each case must be judged by its own peculiarities. If the collapse is complete, no great harm is done if it is left alone, that is, in those cases in which the fluid appears insidiously. It does, however, sometimes worry and alarm the patient, and the splashing is a nuisance. In these cases it is well to tap. If left alone, in cases of complete collapse, it is liable to produce an obliterative pleurisy, and stop the pneumothorax. This is quite a useful way of completing the treatment, and in several of my cases this happened. If however, the pneumothorax has not been instituted long enough for a cure to have taken place, it is advisable to tap and replace by air. Where the fluid co-exists with a systemic intoxication it is well to remove it, as there is then an alleviation of the symptoms. Where adhesions are present, if fluid arises, it should be tapped, as there is much more likelihood of an obliterative pleuritis occurring after this procedure.

Pleural Shock.

Pleural Shock is a rare accident, and it has

never happened to me during an induction or a refill, but I have seen it on one occasion whilst removing an ordinary tuberculous effusion. What is described as pleural shock very often is due to an idiosyncrasy to cocaine or possibly to sudden mediastinal displacement.

Pain.

The only pain of any importance in cases of artificial pneumothorax, is due to a pleurisy. Quite often the effusion is painless from the beginning, but occasionally it is ushered in by pain which persists for many weeks, and is often accompanied by a low fever.

Dyspnoea.

Dyspnoea is only present in unilateral cases if an overdose of air has been given, but it does occur in bilateral cases, and is rather distressing to the patient, especially after a refill.

Displacement of the Mediastinum.

There is usually a certain amount of bowing of the mediastinum, especially in the early stages of the treatment. It does not, as a rule, cause any trouble and it gradually passes off later. It seems that the

mediastinum becomes anchored. The displacement in the early stages must be carefully observed by X-ray screening, and the amount of air and the spacing of the refills judiciously arranged.

Other Complications.

Other complications such as pleural hernia, puncture of the pericardium, or big blood vessels can only occur as very rare accidents, or else are due to carelessness. Empyema is a rare complication of collapse therapy and only occurred once in my series, and luckily responded to tapping and air-replacement.

Methods of Fluid Replacement.

It is said that it is advisable to replace the fluid by air at the one operation as there is a possibility of mediastinal displacement or even pulmonary oedema, but it is much easier to do one part at a time, and after draining the fluid with a Burrell's apparatus, the necessary amount of air can be put in through the same needle and if the usual care be taken no danger is likely to be encountered.

Gas Embolism.

, Gas Embolism seems to have been a not uncommon complication before the introduction of the manometer. I have never seen it happen, and it should be a very rare event. The most likely time for it to occur would be at the induction of a collapse if the needle were accidentally introduced into the lung.

Duration of Treatment.

This depends on the extent of disease which is present at the beginning of the induction. A collapse will naturally be kept up for longer periods if there were signs of cavity-formation than if only a mild degree of consolidation were present. The duration of treatment will also depend on the activity of the disease before induction, and the greater the systemic intoxication, the longer the artificial pneumothorax would be kept up. It depends also on whether there was complete collapse or whether adhesions had permitted only a partial one. The more completely the lung is rested the earlier the treatment can be stopped. The appearance of complications, such as serous effusions, especially in the early stages would tend to lengthen the duration of the pneumothorax. Empyema also makes one lengthen the

time of treatment. The attitude of the patient has occasionally to be considered, and in some cases will cause the treatment to be stopped prematurely. A certain number have such a fear of a recurrence of the disease that they refuse to stop treatment, and one does not feel inclined in those cases to refuse their request. In a certain number of cases the termination is due to active disease of the other side or to an obliterative pleurisy. Sometimes an asthma or a bronchitis in the better lung may cause its cessation. No patient in my series has deliberately refused to continue treatment, and this is due to the gaining of the patient's confidence from the very start. Therefore, one cannot estimate when to terminate treatment in terms of a time limit. In my series of cases the average time was rather under two years for all cases, but that includes those that either died or had to stop treatment entirely. In the cases that have been terminated because one thought there was no longer any reason to go on with the treatment, the average direct duration of treatment was three years.

Adhesions.

An artificial pneumothorax can only be induced when there is a free pleural space. Adhesions are the commonest cause of failure of the treatment, either they prevent any air entering or else they only allow the entry of such small amounts of air that the collapse is quite inefficient. It is difficult to say in what percentage of cases adherent pleura is met with and different reports have computed it at from 7% to 20%.

There is only one way to make sure that extensive adhesions are present and that is to try to produce a collapse of the lung, although an attempt should always be made beforehand to diagnose their presence so as to warn the prospective patient that collapse of the lung may not be possible. One may say that it is more likely to find a free pleural space in those cases with early, localised disease and this point has been laboured as an indication by those enthusiasts who advocate collapse therapy in early cases. A good tidal excursion especially of the bases of the lung will suggest a free pleural space, whereas in a case with a previous history of pleurisy and perhaps physical signs suggesting a thickened pleura,

it is unlikely that a good collapse will be secured.

The manner in which the needle passes through the pleura will usually tell the experienced operator whether he is dealing with an adherent pleura or not; with a free pleural space the Riviere's blunt cannula goes through the parietal pleura with a snap, whereas if the surfaces are glued together by adhesions no such sensation occurs, and it is in these cases that inexperienced operators push on and puncture the lung with the risk of gas embolism.

It is advisable to try repeatedly before abandoning a case as one of adherent pleura, as in Case 21, it was only at the fifteenth attempt that a very small pneumothorax was secured.

Degree of Adhesions.

It is exceptional to have a case that does not show after induction some form or other of this condition. One may find that a certain quantity of air can be introduced, but adhesions prevent the major portion of the lung from collapsing and it is found in these cases that the manometric pressures increase very rapidly although only small quantities of air are introduced, and on X-ray examination a very limited pneumothorax is seen. It is surprising that even this

small collapse will sometimes help to slow up the disease and would help more if it could be maintained for long periods, but unfortunately in many cases an obliterative pleurisy wipes out the collapse.

Localised adhesions at the site of the disease especially where a cavity has formed will sometimes prevent the collapse of the very area that is doing most damage. Thin strands of adhesions are also met with which are not so inelastic and gradually stretch under a steady pressure and allow complete collapse to take place.

The only fear of this type of adhesion is that it may become the starting point of an obliterative pleurisy. Breaking or tearing of adhesions sometimes occur during the course of treatment but I have not seen any unpleasant sequelae from this rupture.

The treatment of adhesions depends on the character, and if in the form of bands, an attempt may be made to cauterise them by means of an operating thoracoscope. Its successful use requires a good deal of practice and there are distinct risks associated with its use. It is advisable to cauterise adhesions only when one is convinced that it is absolutely necessary, and this will very

seldom occur. All that the collapse therapist can do is to try by increased air pressures to stretch adhesions if in the form of bands, care being taken not to produce a spontaneous pneumothorax.

The surgical treatment of adhesions is either by avulsion of the phrenic nerve which has not in my experience done any good, or else a thoracoplasty may be attempted. It is a very serious operation and has a high mortality; as well one has to make very sure that the other lung will not break down, because if this happens in an artificial pneumothorax, one can always allow the collapsed lung to re-expand, but in thoracoplasty no such procedure can be undertaken.

Finally one may say that it is most aggravating to find densely adherent pleura preventing the establishment of an artificial pneumothorax in what otherwise appears to be a most suitable case.

Notes of Cases.

Case 1. Male, aet 39. Boiler Maker. 13S
(Philips classification.)

Admitted to the Johannesburg Hospital on the 21st of September 1928 complaining of haemorrhages from the lung. These dated from the onset of his symptoms three years previously. On admission he was bringing up about four ounces of sputum daily which contained tubercle bacilli. The haemorrhages had been getting increasingly severe and frequent following his discharge from Nelspoort Sanatorium three months previously. On examination he was extremely ill, rapid pulse, and persistent temperature. There was evidence of cavity formation of the left lung, and a fair amount of disease of a fibrotic type of the right.

Treatment.

An artificial pneumothorax was induced on the 3rd November 1928 on the left side, and was successful on the first attempt. He was refilled as previously described. Luckily few adhesions were encountered. The result was there were no further haemorrhages, and he was discharged on the 4th February 1929 from Hospital, and treated as an

out-patient. He is still alive, although he suffers from a certain amount of bronchitis and asthma due to the fibrosis of the right lung. It was this complication, and the persistent presence of tubercle bacilli in the sputum which caused the cessation of the treatment in November 1929. The treatment was used entirely as a palliative measure. One realised it was only to prolong life. The case must be classed as a success as he is still alive, whereas in view of his recurrent and profuse haemorrhages, his chances before induction were small.

The X-Ray photograph shows a fairly good collapse except at the apex where a cavity is seen held up by adhesions.

In spite of this appearance no further haemorrhage occurred.



Case 1.

After treatment.

Case 2. Aet 49. Storekeeper. $1_2S +$ Diabetes.
Admitted to the Johannesburg General Hospital 24th
April 1928.

Complaint. Sugar in his urine, and tubercle
bacilli in his sputum.

He stated that about a year previously he
had noticed a loss of weight, with excessive thirst,
and that sugar in his urine had been found by his
doctor.

Treatment had been successful in so far
that his symptoms had disappeared, but about six
months later a cough started with sputum in which
tubercle bacilli were found. He was sent to the
Orange Free State, but had rapidly got worse.

Examination. He was a big-framed man who had lost
about forty pounds in weight. There was a large
quantity of sugar in his urine. Chest examination
showed the whole of the upper lobe of the right
lung affected by a tuberculous consolidation. On
investigation it was found that the blood sugar was
.25%. The case seemed urgent, and a full diet
was ordered with sufficient insulin to keep his
urine sugar free. As soon as this appeared, it
was found that his blood sugar had come down to

.16%. An artificial pneumothorax was induced with success. The general improvement was dramatic. The insulin necessary before the institution of the pneumothorax was 60 units daily. A few days afterwards, ten units was found to be sufficient to keep him sugar free. Within ten days, his blood sugar was .11 and insulin was stopped, and has not since been necessary.

He was discharged from Hospital on the 22nd June 1928, urgent business recalling him to Durban, The result was that a large effusion developed, which had to be tapped and replaced by air. Since then he has done well. There has been no recurrence of his diabetes. His blood sugar has remained at .1%. He has put on nearly all the weight that he had lost. The pneumothorax was discontinued six months ago.

Case 3. Female. Aet 28. Costumier. 1₂S.
Admitted to the Johannesburg General Hospital 1st October 1926, complaining of haemoptysis one to two ounces at intervals for the past year. She also had a cough with tubercle bacilli in the sputum and there had been progressive loss of weight and vigour. On examination she was rather under-nourished, pale and anaemic with evidence of consolidation of the right upper and middle lobe of the lung. A pneumothorax was induced on the 21st October 1926, perfectly successfully but was never complete as adhesions prevented full collapse. Exigencies of business prevented her having absolute rest for a prolonged period. The result was that after about six weeks, fluid developed in the pleural cavity, and was of a purulent nature. The fluid was tapped and replaced by air on several occasions, and finally it dried up. The pleurisy was a most unusually painful one. No other complications of any kind arose, and the treatment was finally discontinued on the 1st September 1929. The result has been excellent in spite of the difficulties of obtaining sufficient rest. She ran a big business and her daily attendance there was essential.

Case 4. Male, aet. 21. Traveller. 1₁S.

Admitted to the Johannesburg General Hospital, 29th October complaining of spitting of blood and slight cough with tubercle bacilli present in the sputum. He also complained of repeated "influenzal" attacks.

Examination. He was well nourished but rather pale and toxic with a pulse rate persistently around a hundred, and a swinging temperature. There was infiltration of the right apex, but it was not very marked. He and his family refused sanatorium treatment although he appeared to be a very suitable case. A pneumothorax was begun on the 29th November 1927, as he was not able to be treated in any other way. He was discharged from hospital on the 14th January 1928, after a complete collapse had been obtained. He came up regularly for refills and treatment finally ceased on the 9th June 1929. He reports at regular intervals, and has kept perfectly well. He did not develop any marked effusion, nor any untoward symptoms at his refills. The results had been very good but he would have obtained the same results if he had gone to a sanatorium.

X-Ray shows complete collapse of right lung.
Fluid is present in right pleural sac.





Case 4.

After treatment. Showing also small amount
of fluid at base.

Case 5. Aet 27. Engineer. L₁S.

Admitted 16th April 1927, complaining of irritation of the throat, loss of appetite, and night sweats. There was also cough, and haemoptysis. His voice gradually became hoarser. He stayed at at Beaufort West for six months and later went into the sanatorium which is in the vicinity.

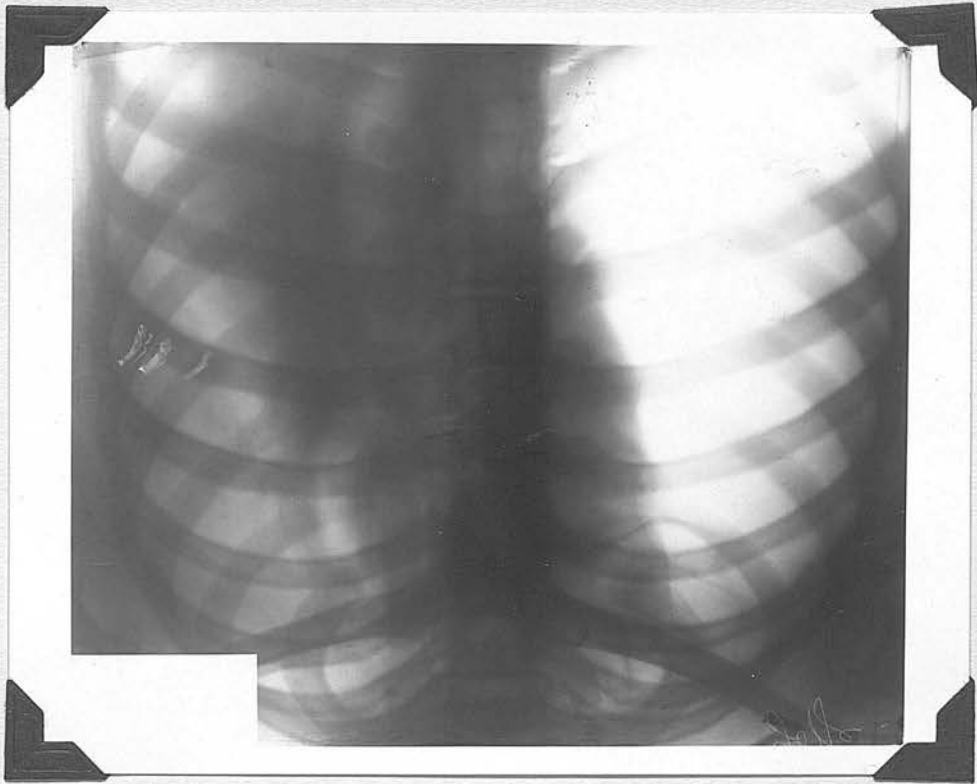
Examination. He is a well nourished man, with a hoarse voice with a slight evening temperature and an increased pulse rate. The left upper lobe was consolidated, and the larynx showed definite signs of tuberculous infiltration. Tubercle bacilli were present in the sputum. A pneumothorax was decided on more on account of the laryngeal condition - the aim being to cut down the cough and sputum and give the larynx a better chance to heal. Collapse was obtained satisfactorily, and the results were excellent. He was discharged from hospital on the 7th September 1927, and after a few months began light work. The voice returned, and later examination showed no active lesion of the larynx. He remained well until he developed an effusion which started an obliterative pleurisy -

finally causing the cessation of the treatment.

Last filling 3rd April 1929.

Case 6. Female. Aet 16. Scholar. L₂S.

Admitted to Hospital on the 6th August 1925 complaining of cough, sputum, and loss of voice. Her symptoms had begun about six months previously with a high temperature which was diagnosed as typhoid fever. At the time she was in a nursing home there was very little cough, but her temperature took six weeks to settle. The cough and sputum had gradually increased, and six weeks previously she had noticed a hoarseness of the voice, and occasionally could not make herself heard. There had been a loss of weight and occasional night sweats. Her mother suffered from chronic pulmonary tuberculosis. She was well nourished, but had lost weight, and a rather pale and sallow complexion. The right lung showed marked consolidation of the upper lobe. There was no evidence of cavity formation. The left lung was clear both to clinical findings and to X-Ray examination. Tubercle bacilli were present in the sputum. The larynx showed slight tuberculous infiltration. It was decided to collapse the right lung, and this was successfully performed on the 15th August 1925. A complete collapse was



Case 6.

After treatment.

Case 7. Male. Aet 28. Pharmacist. 1₂S.

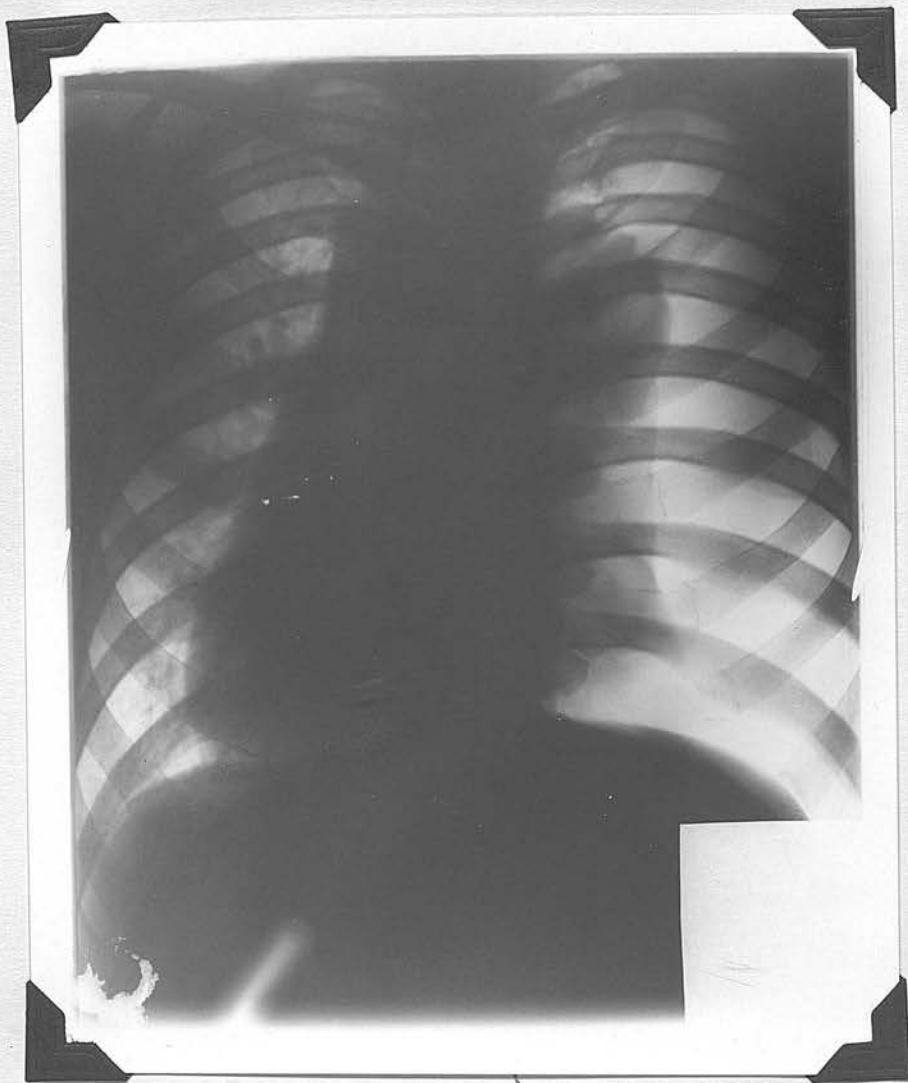
Admitted to the Johannesburg Hospital complaining of cough which had begun a few months earlier. There was no sputum at first, but it had gradually started and got progressively more profuse. He was running a high temperature at night and losing a lot of weight and had night sweats. He had no interest in his work and was always tired. There had been no haemoptysis. His sputum had been examined and tubercle bacilli were found to be present. On examination he was sallow and toxic and had obviously lost weight. The right upper and middle lobes were involved by a tuberculous consolidated condition which seemed of a broncho-pneumonic character. There was no possibility of getting him into a sanatorium, and he, on economic grounds preferred to have an artificial pneumothorax. An induction of the right lung was started on the 15th March 1926, and complete collapse was successfully attained. He was kept in bed rather longer than the average case on account of the local lesion being of such malignant type, but he had no untoward symptoms, and he was discharged for out-patient treatment on the 4th August, 1926. His refills

were kept up at regular intervals until June 1928, and then stopped. Since then he has been working at his trade and had no recurrence of his disease, and has kept perfectly well.

X-Ray shows right sided complete collapse. There is a slight displacement of the Mediastinum to the left. The first film shows a typical case of L_2 disease.



Case 7.



Case 7.

After Treatment.

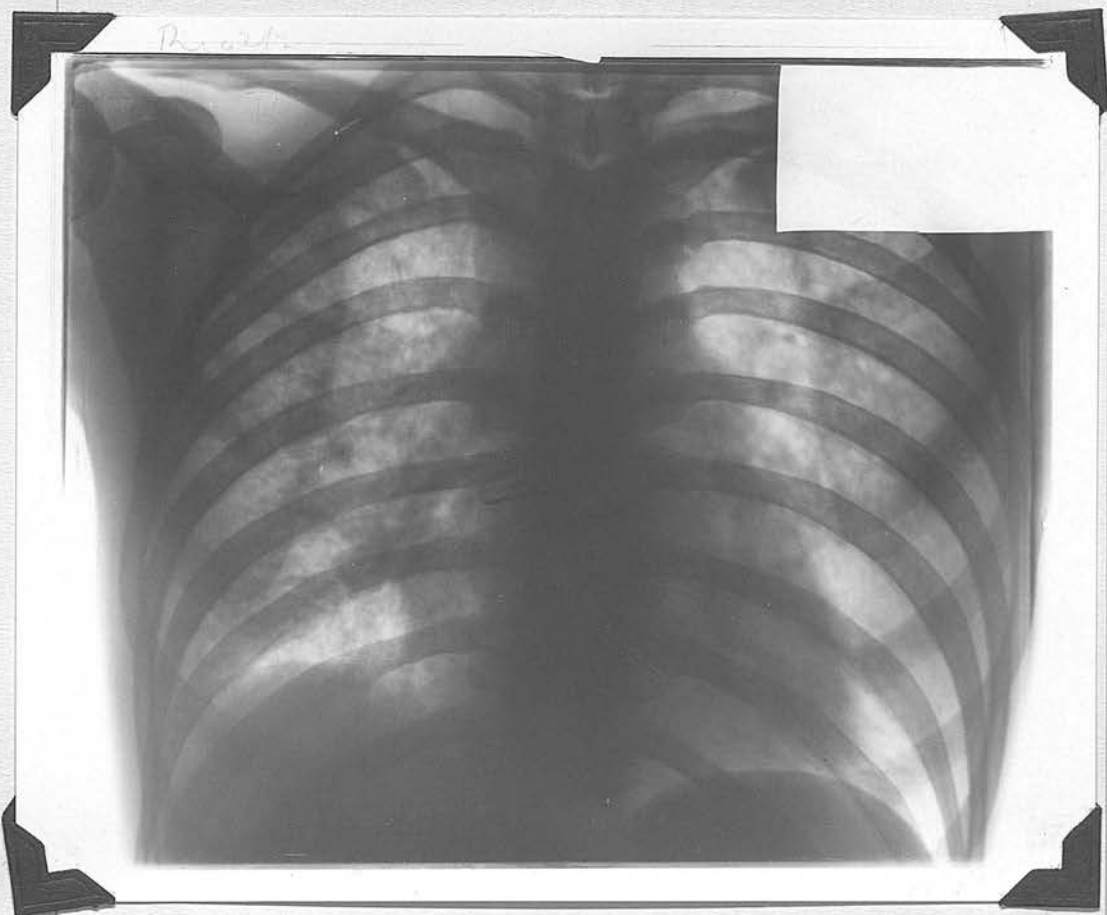
Case 8. Female. Aet 26. School Teacher. 13S.
Admitted to the Johannesburg General Hospital on
3rd September 1924 complaining of cough. In
December 1922, suddenly one night she spat up some
bright, red blood. She did not feel ill at the
time, but the cough developed soon after this which
was dry in character. Sputum did not start until
March 1923 when she developed "pneumonia". At
this time she spat up about a cupful of pure blood.
The cough became worse, she was very feverish, and
sweated a good deal both day and night. She had
pain over the right chest. This gradually improved,
but about six weeks later she got another attack, and
again brought up blood and the cough got progress-
ively worse, and she became short of breath. On
examination she was very thin and toxic. There
was evidence of disease of both lungs, but the
right lung clinically was that of a tuberculous
bronchopneumonia. On the left side the disease
was not very far advanced but clinically and radio-
logically there was undoubted infection. Her
temperature was high and of a septic character,
and her pulse rate was persistently about a hundred.
It seemed a hopeless case but the only chance that

she had was to do a pneumothorax. One hoped that in the general intoxication could be diminished it might give the other side a chance to heal. The collapse was induced on the 17th September 1924, and very gradually a fair degree of collapse was managed. An adhesion at the apex prevented its completion. This adhesion slowly stretched and finally a total collapse was achieved. The symptoms began to slowly improve, but it took several months before the systemic intoxication disappeared. The left lung at no time showed any further involvement, and finally fibrosed up. In August 1925, she was found to have a serous effusion and that had to be tapped and replaced by air, otherwise no complications arose. The treatment was stopped on the 21st December 1927 having been kept up for over three years. She has had no recurrence of symptoms. She is not a very robust person even now although she says she feels better than she ever did. The tuberculous process is, at least, quiescent, and even perhaps healed. She has now stayed well for about three years, what is finally going to happen one cannot tell. The pneumothorax undoubtedly saved her life; she was too

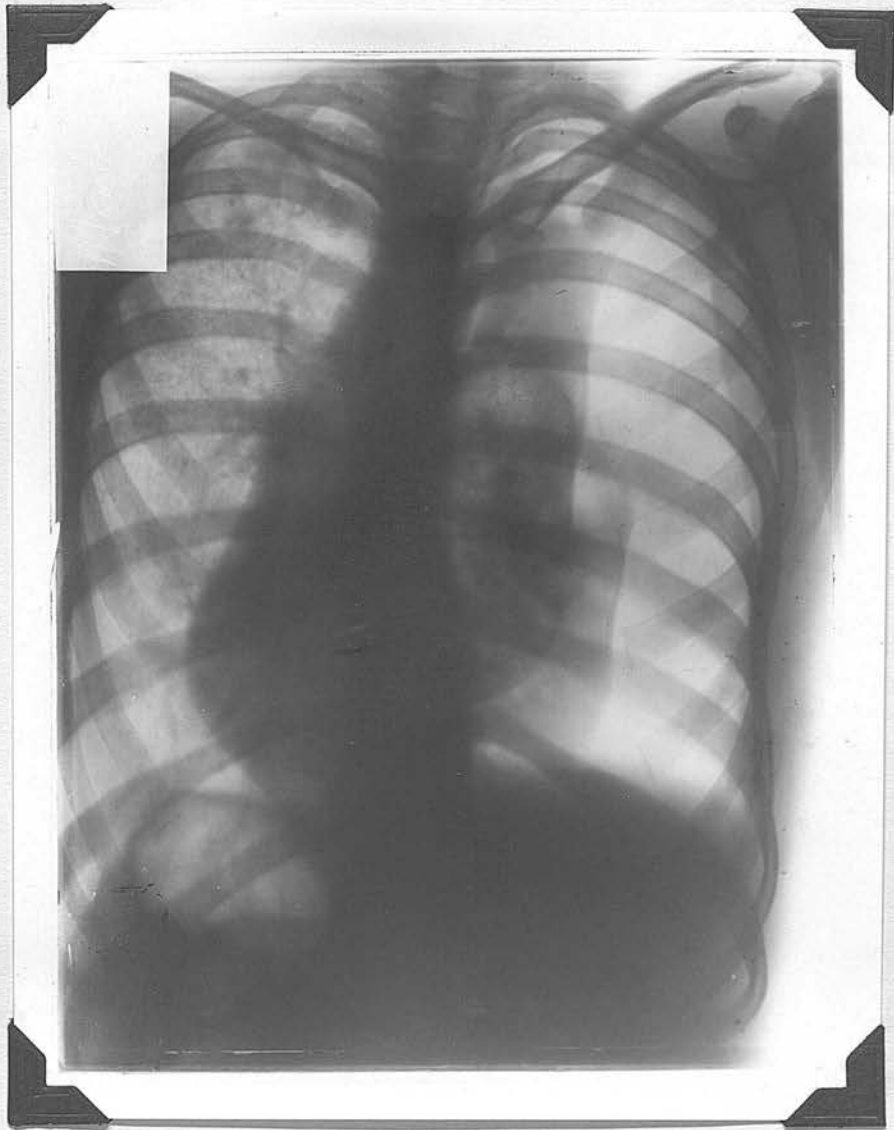
advanced for any other method of treatment to have been of any use.

X-Ray shows extreme degree of disease of the right lung with cavity formation and the left lung is also involved.

The second X-Ray taken six months later shows good collapse except for an apical adhesion and illustrates how the contra-lateral lung can clear up after an artificial pneumothorax.



Case 8.



Case 8.

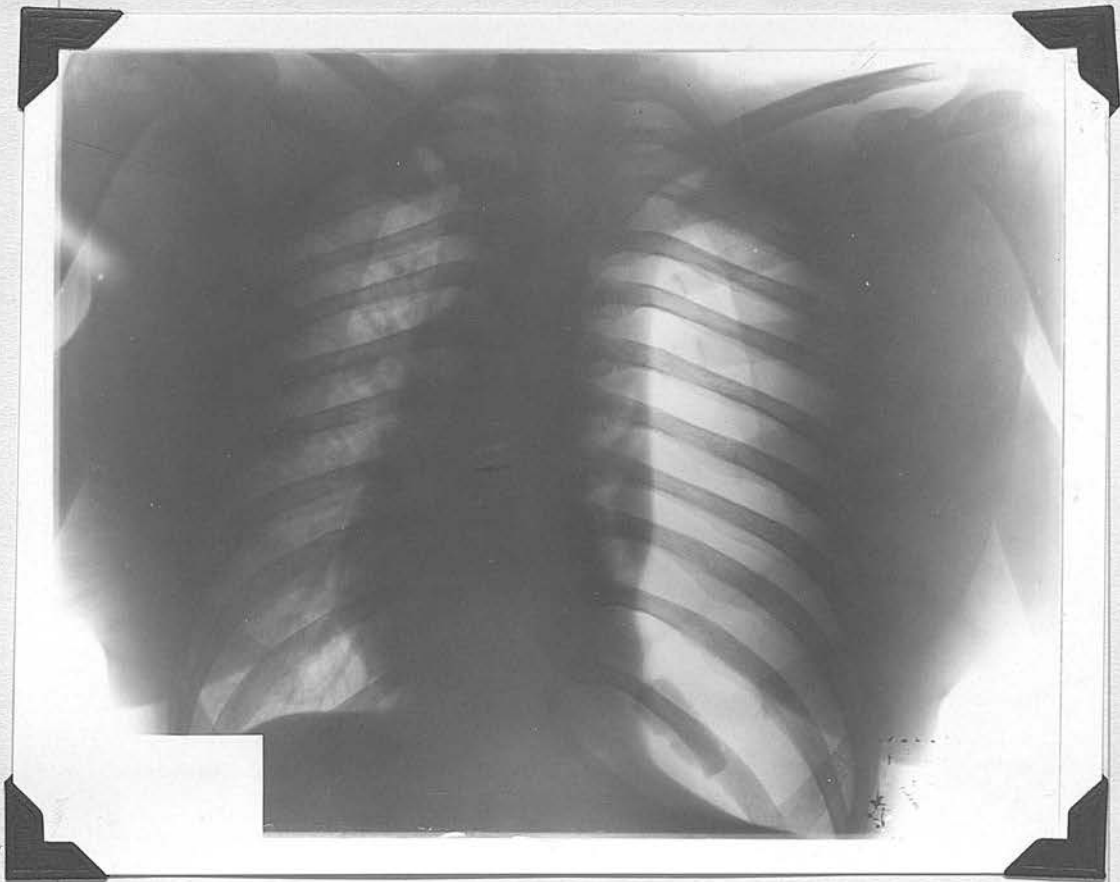
After Treatment.

Case 9. Female. Aet 26. Housewife. 1₂S.

Admitted to the Johannesburg Hospital on the 12th May 1925 complaining of cough and sputum, and a slight haemoptysis. She started in January 1924 with a slight cough of a dry character which had gradually got worse. Later there began to be a certain amount of sputum, and about two months later she noticed streaks of blood in her sputum which was then examined and found to contain tubercle bacilli. She had lost about a stone in weight, had marked lassitude, and suffered from night sweats. She had been sent to the sanatorium where she improved, but was discharged after three months. She had lived on a farm, and had gradually gone back, until all her old symptoms, which had cleared up almost entirely in the sanatorium, returned. On physical examination there was a fair amount of consolidation of the left apex of the lung. As admission to the sanatorium was not again possible, a pneumothorax was induced on the 20th May 1925. A complete collapse was successfully attained, and was kept up for three years. No complications of any kind were ever encountered.

The toxaemia rapidly cleared up and she is now completely restored to health.

X-Ray - there is complete collapse of right lung.



Case 9.

After treatment.

Case 10. Male 33. Carpenter. L₂S.

Admitted to the Hospital 5th September 1922 complaining of spitting up of blood. He stated that he had come out to this country about two years ago from the north of Scotland, and had kept quite well to the end of 1924, when he began to cough and finally brought up an egg-cupful of blood. He became easily tired and unfit to do his work. He was admitted to Nelspoort Sanatorium and remained there for three months. He improved a good deal, put on weight, and regained his vigour. There was no further bleeding, although he did not lose his cough, and brought up a small amount of phlegm every morning. After his discharge, he came to Johannesburg, and started to work, but noticed that all his old symptoms began to reappear, and finally he once more started to bleed.

Examination. There was not a very marked amount of disease but there was fair amount of infiltration and early consolidation of the left upper lobe.

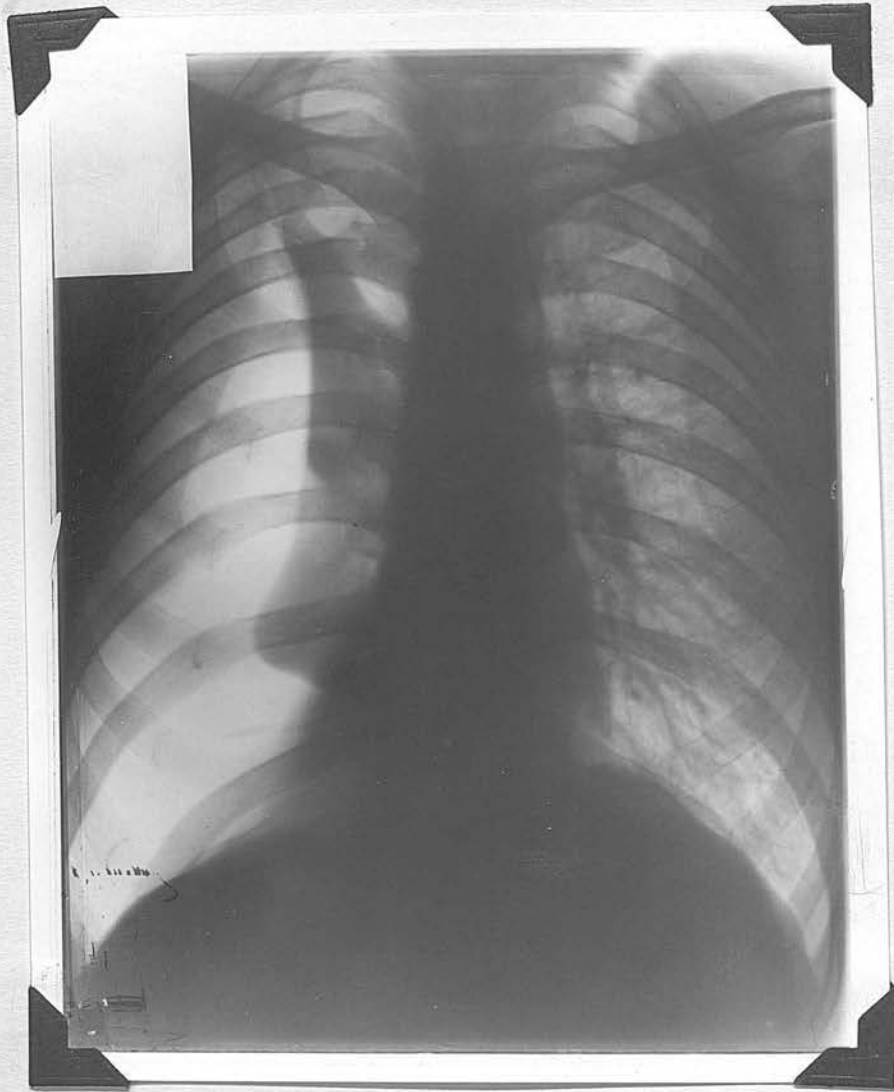
It was to some extent fibrotic. He was found to have an evening temperature, and tubercle bacilli were present in the sputum; a pneumothorax was successfully initiated on the 12th September, 1925,

and a complete collapse was eventually obtained. He was discharged to attend as an out-patient on the 13th January 1926. The treatment was stopped in June 1927, and he made a complete recovery, and at no time developed any effusion or untoward symptoms. He has kept well since then and is now doing farm work, his occupation as a carpenter being thought too strenuous.

X-Ray shows a good collapse except for an adhesion at the left apex.



Case 10.



Case 10.

After treatment.

Case 11. Aet 28. Civil Servant. L₂S.

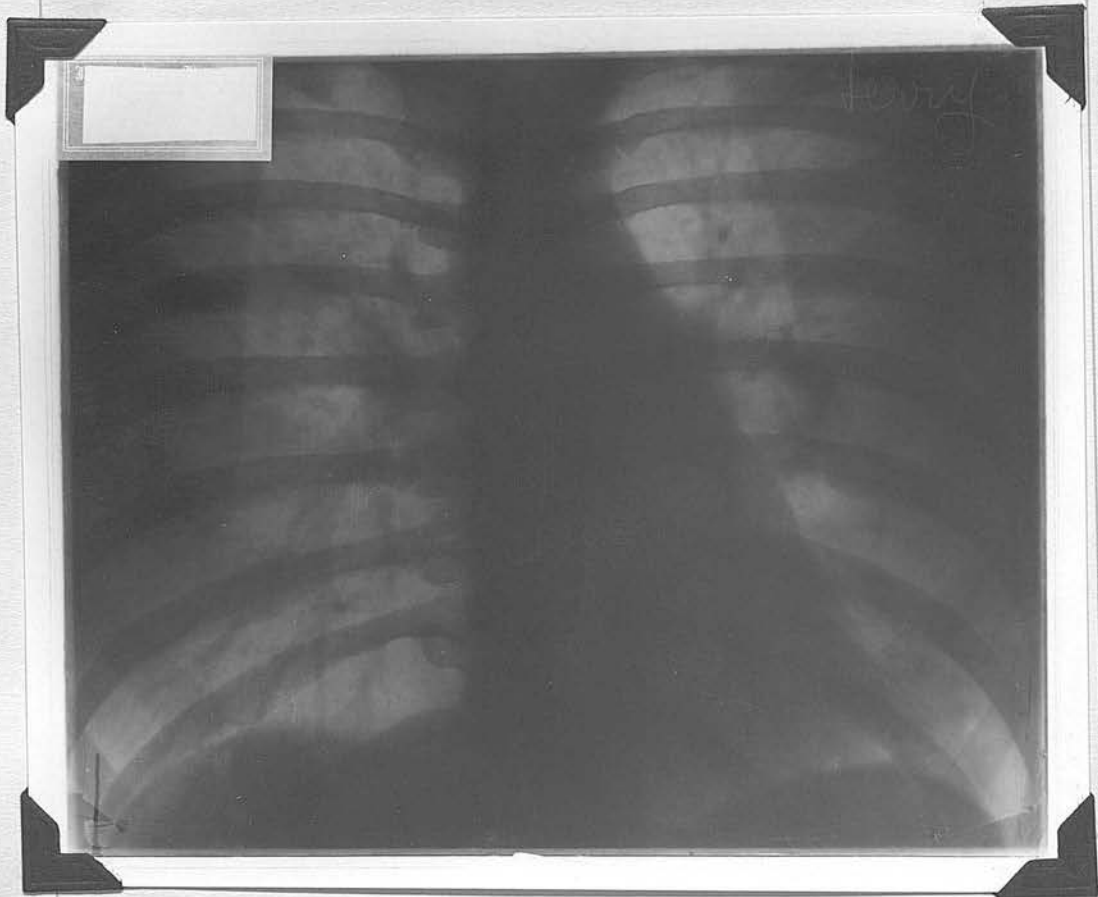
Admitted to the Johannesburg Hospital 16th November 1924 complaining of cough and sputum which had been present for about three years. Latterly her voice had been getting hoarse. She had been told that she had "consumption" three years before and had given up her work and lived in the Free State but her condition had not improved.

Examination showed a well marked tuberculous consolidation of the right lung and the larynx was also affected by the disease.

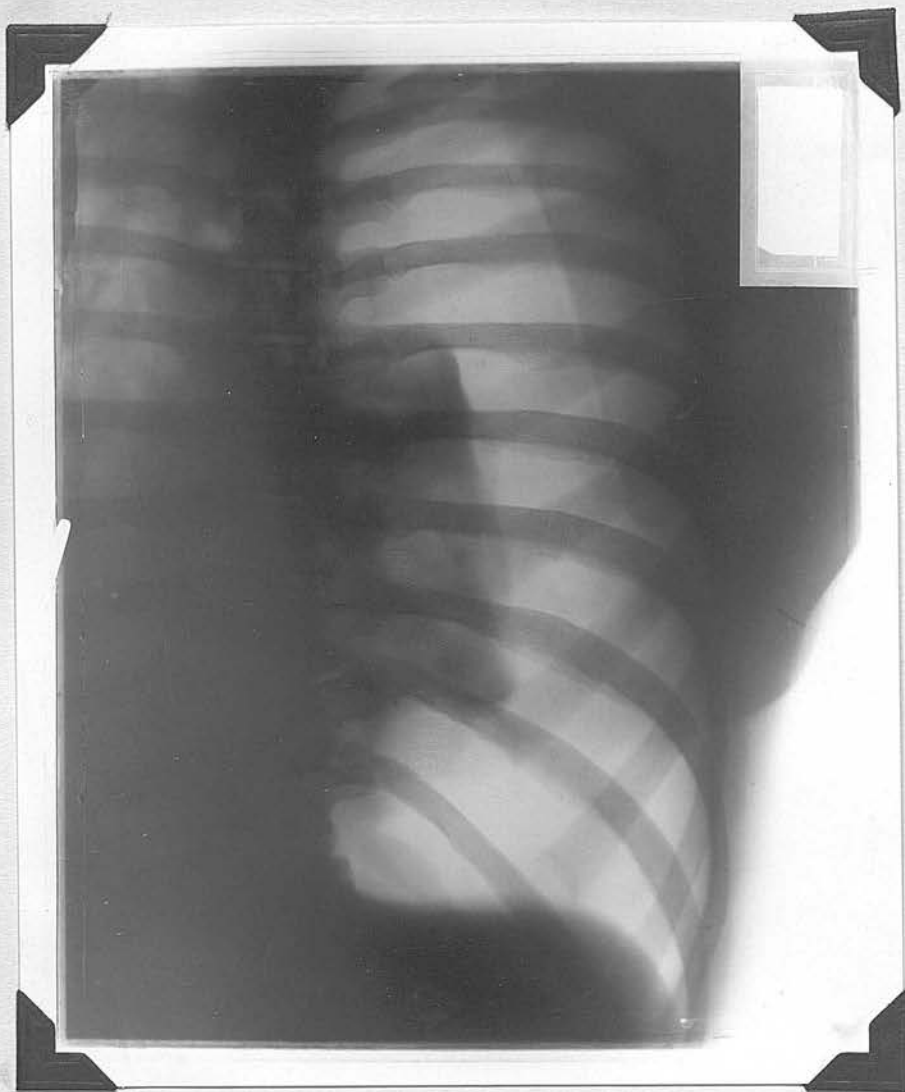
Pneumothorax was started on the 4th December 1924, and a complete collapse was obtained. She was kept in hospital for about four months as her temperature took rather longer than usual to settle and she was finally discharged to attend as an out-patient on the 8th April 1925. The collapse was maintained until the 4th September 1926 and no complications of any kind occurred during the treatment. She has kept well up to the present. Her voice gradually came back. She had had in the past a double mastoid operation, and on admission had a discharge from both ears. As her general condition improved the otitis cleared up and she had

no recurrence.

X-Ray. The first X-Ray shows a typical stage ii case and the second film demonstrates a very excellent collapse.



Case 11.



Case 11.

After treatment.

Case 12. Male. Aet. 21. Engineer. L₂S.

Admitted to the Johannesburg General Hospital complaining of cough. Sixteen months previously, while in Australia, he brought up a cupful of blood. He did not take any notice of this thinking it was due to a strain. Later he developed a cough and sputum. He gradually became weaker and lost a lot of weight. It was these symptoms that made him consult a doctor who advised him that he had "consumption". He went into a sanatorium in Australia where he stayed for eight months. From his history one gathered that there had been a persistent temperature which only very slowly settled. Family reasons finally decided his transference to South Africa. On examination he had consolidation of the left lung and unfortunately there was evidence of definite disease of the right lung as well, which was confirmed by X-Ray examination. A pneumothorax of the left lung was successfully induced on the 26th February 1925, and finally a complete collapse was obtained. The systemic intoxication rapidly cleared up, the sputum and cough disappeared, and the other lung simply fibrosed. He was discharged from hospital for

out-patient treatment on the 31st May 1925. He did not develop any complications or untoward symptoms. The treatment was terminated on June 1928. He has been seen regularly since then, and has kept quite well. He is able to do office work, and also to play golf.

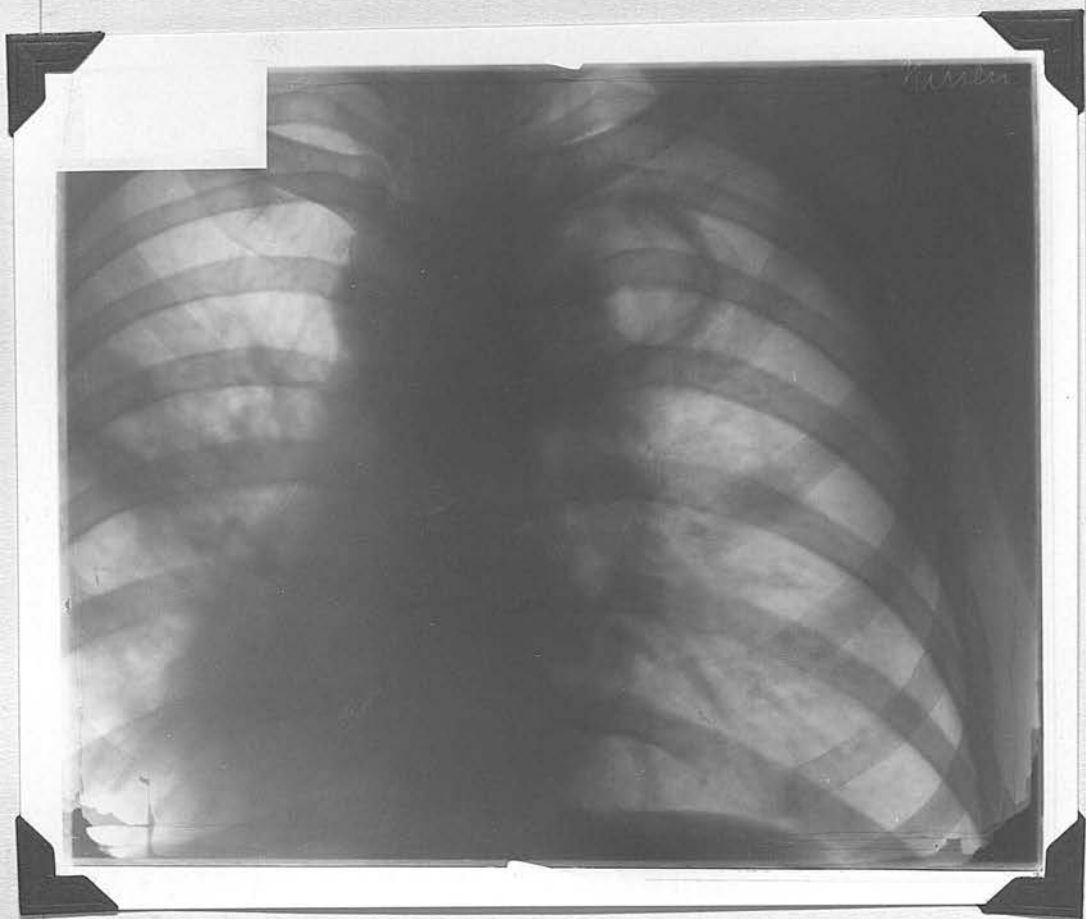
Case 13. Male. Aet. 29. Pharmacist. 1₃S.

Admitted to the Johannesburg Hospital 22nd February 1926 complaining of cough, night sweats and loss of weight. His symptoms started eighteen months ago with a severe "cold". He brings up a lot of thick green sputum and had lost about thirty pounds in weight the last year. The night sweats had been less profuse from the time he went to the sanatorium, where he was an inmate for three months, and had been discharged some six months before admission to hospital.

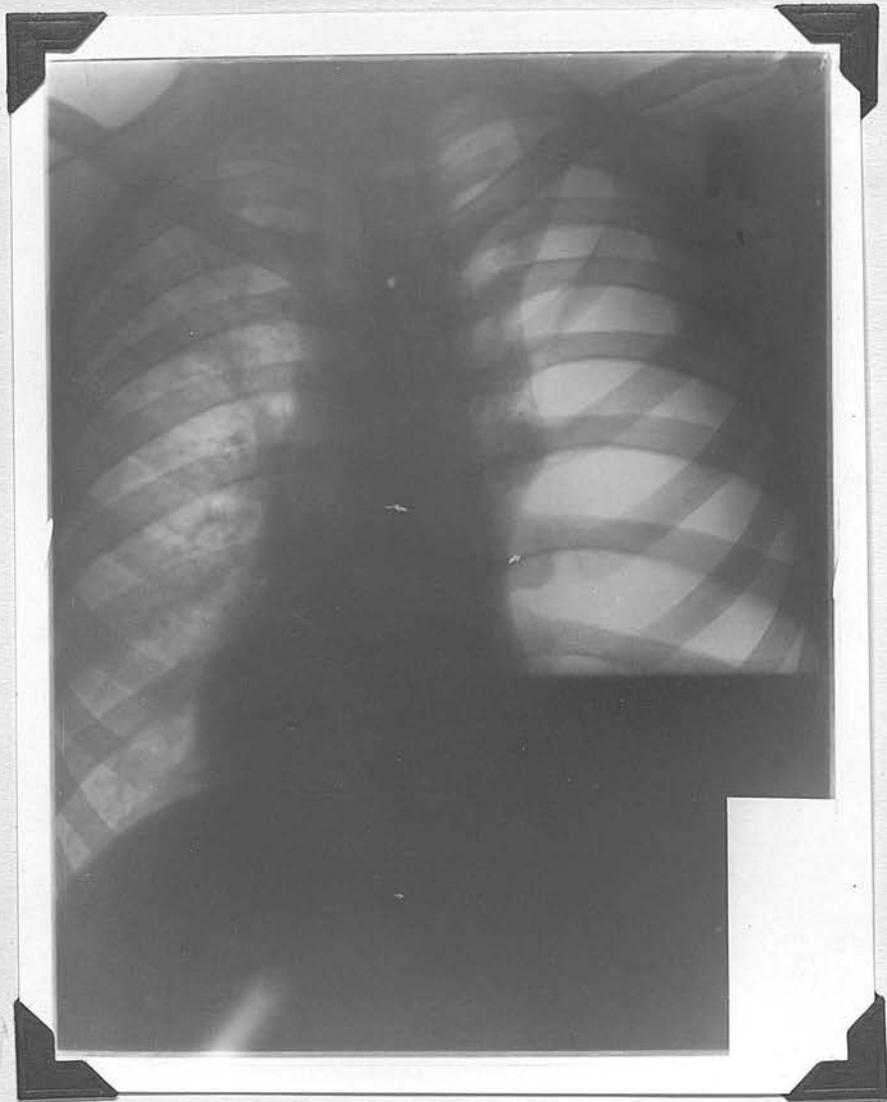
On examination he was very thin, and had symptoms of severe toxæmia. There was a cavity at the right apex, and some evidence of disease of the left lung in the axillary region. A pneumothorax was induced on the 16th March 1926, and a fair degree of collapse was finally secured, an adhesion preventing a complete collapse. He was kept at rest for a longer period than usual, as the signs in the left axilla took a long time to clear up. He was finally discharged, and again sent to the sanatorium on the 3rd September 1926, where his refills were continued. Since his discharge he has been in Johannesburg under my care. He

developed an effusion in June 1927 which was tapped and replaced by air. Slowly an obliterative pleurisy prevented the usual quantities of air being introduced and in June 1928 the pneumothorax had to be abandoned. He is not a fit man, but is able to do light work as a pharmacist, and earns his own living. He has had no recurrence of his symptoms, but the disease has left its mark. His future cannot be prognosed.

X-Ray. The film before induction shows both lungs extensively diseased, a cavity is to be seen at the right apex. The collapse is very good and the cavity has been obliterated but there is an adhesion at the apex. Some fluid is shown in the left pleural sac.



Case 13.



Case 13.

After treatment showing fluid.

Case 14. Female. Aet 22. Housewife. 1₂S.

Admitted to the Johannesburg Hospital on the 8th January 1924 complaining of a cough following the birth of a child about six months previously. In the last six months she coughed and brought up a lot of sputum. There was considerable loss of weight, night sweats, and lassitude and at times she felt feverish. On examination there was involvement of the whole of the left lung, by consolidation and infiltration, and no disease of the contra-lateral lung was made out. She was extremely toxic. A pneumothorax was induced on the 21st January 1924 and a complete collapse was secured. Her toxic symptoms fairly cleared up, and she was discharged on the 2nd March 1924 for out-patient treatment. Her weight remained stationary for a considerable time, but eventually improved. In view of the severity of the toxaemia prolonged rest was ordered. There were no complications and the treatment was finally terminated in June 1928. She has stayed well, although not a very robust woman.

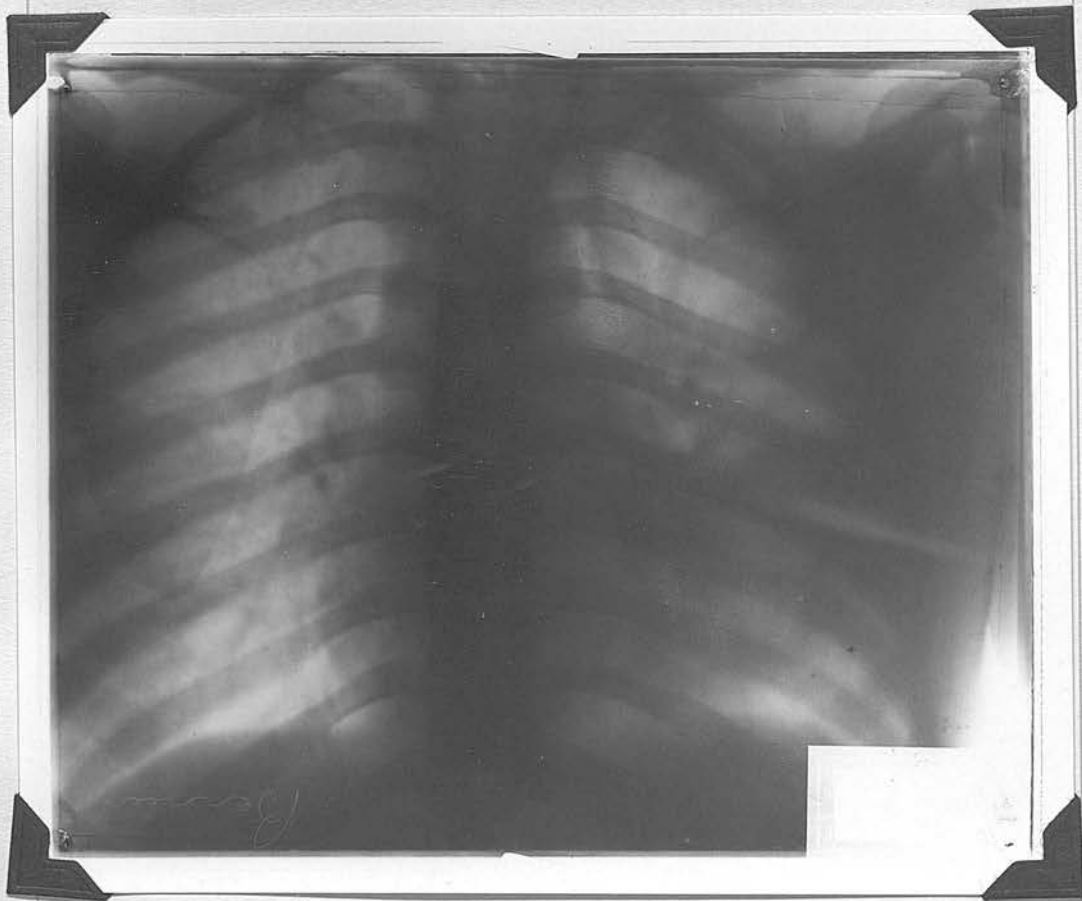
Case 15. Male. Aet 32. Builder. L S.
2

Admitted to the Johannesburg General Hospital on the 6th June, 1923, complaining of cough and shortness of breath. His symptoms had begun during the war, and after his discharge in 1918, he had noticed the cough which had gradually got worse, and in 1920 he brought up a little blood. He had spent a considerable time resting in the Free State, and had also been to Nelspoort Sanatorium. His condition had varied from time to time but he had steadily gone down hill as from the date of onset of symptoms. He was not very toxic, and on examination there was consolidation of the left lung which had undergone a fair amount of fibrosis. The other lung seemed clear. A pneumothorax was induced on the 18th June 1923, and although adhesions were encountered, a fair degree of collapse was finally secured. He was discharged on 14th August 1923, to attend as an out-patient. He did not develop any complications and had made a very complete recovery. The treatment was terminated in June 1926. He has not been seen for some years, but when last heard of, was well.

Case 16. Female. Aet. 19. Scholar. 1₂S.

Admitted to the Johannesburg Hospital on the 10th June 1926, complaining of cough. She had first noticed the cough about three years before, and this had slowly got worse, and she began to lose weight and feel more tired than usual. There had often been night sweats and feverish attacks. She had lived in the country but had slowly gone down hill. On examination she was extremely toxic, and the left lung was extensively involved. A pneumothorax was induced on the 17th June 1926, and finally a fair degree of collapse was obtained. Adhesions prevented total collapse. She was discharged from hospital for out-patient treatment on the 7th December 1926. She developed fluid on several occasions during her treatment, but it usually cleared up. On two or three occasions when it became profuse, it had to be tapped and replaced by air. Finally an obliterative pleurisy prevented the continuation of treatment. The last refill being done on September 1929. She coughed for a long time after cessation of treatment but is now quite well and able to do any kind of work.

X-Ray appearances before induction showed marked disease of the left lung and some shadows of the right. There are adhesions at both apex and base preventing complete collapse.



Case 16.

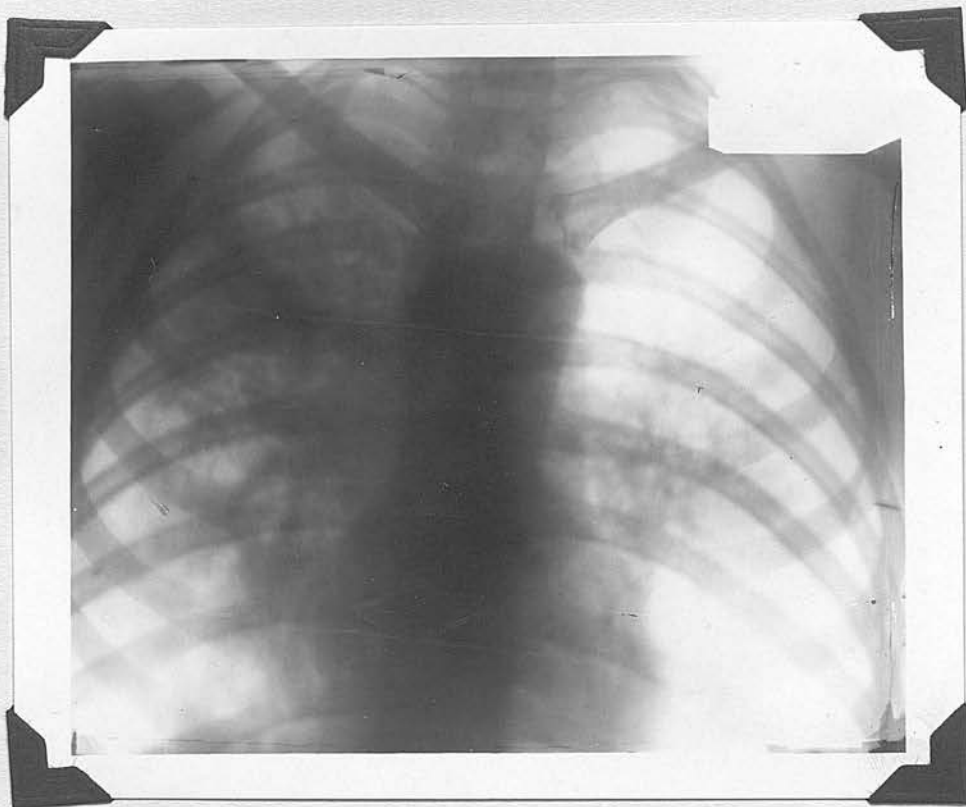
Case 17. Male. Aet 21. Upholsterer. 1₃S.

Admitted to the Johannesburg General Hospital on 2nd November 1927, suffering from cough, sputum and loss of weight. He was well until two months previously. There was no family history of tuberculosis. He had noticed a paroxysmal cough a few weeks before, and sputum had got more and more profuse. There was no bleeding and no pain in the chest, but he had got progressively weaker, and had dropped over a stone in weight in two months. There was marked bilateral disease on examination with evidence of cavitation of both lungs. Tubercle bacilli were present in the sputum. He ran a high and continuous temperature and his pulse rate was persistently over a hundred. The diagnosis of tuberculous broncho-pneumonia was made. The X-Ray confirmed the diagnosis. It was decided that in view of the extreme gravity of the condition, to induce a simultaneous bilateral partial artificial pneumothorax. Induction on the right side was begun on the 17th November 1927 and after 700 c.c. of air had been put into the right side, collapse of the left side was initiated and again no difficulties were encountered. Appended is a chart

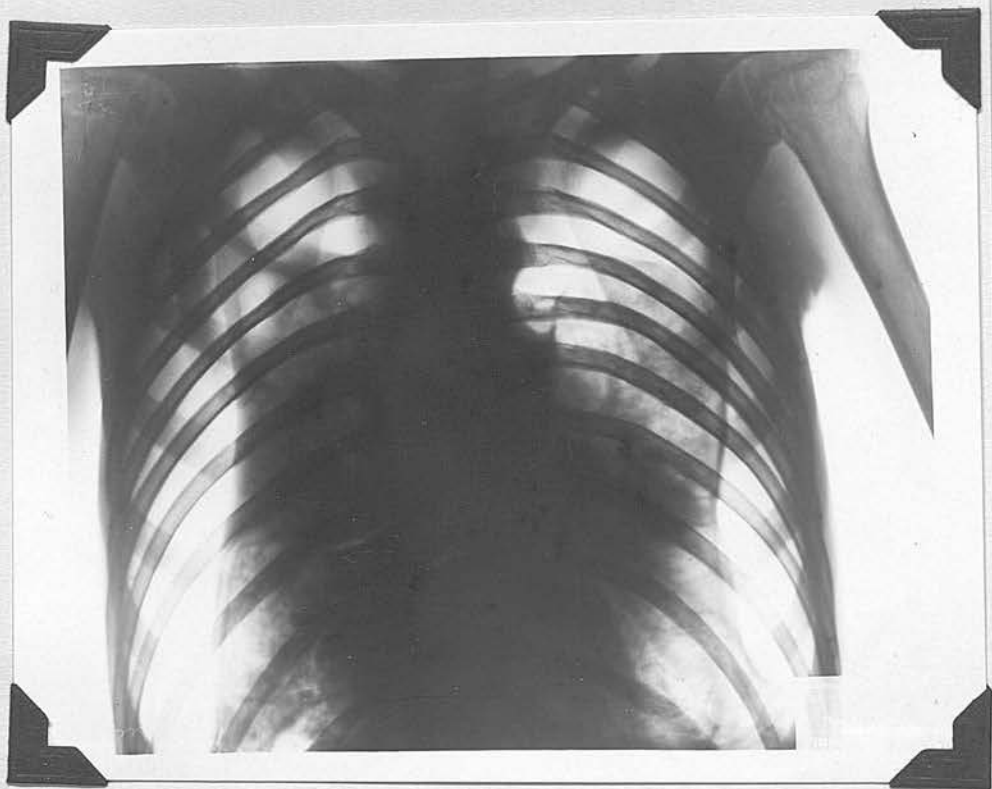
showing the spacing of the refills and the amounts of air induced. A partial pneumothorax of both sides was kept up with a fair amount of relief to the patient who asked for the refills as he said they relieved him. The temperature settled to some degree, but never became normal. His weight kept stationary, and his cough improved, and his sputum lessened in quantity. He stayed fairly well, and at times was able to get up and sit in a chair. The improvement lasted for about a year, but finally the tuberculous process cleared up, and the temperature became higher, the pulse rate increased and he died on the 5th October 1928, about a year after the induction of the bilateral collapse. Unfortunately no post mortem was obtainable.

X-Ray. The disease is more marked on the right side than on the left. This is perhaps better seen in the second film. There are a few adhesions but as great a collapse as was compatible with life was secured without any trouble.

The amounts of air and date follow.



Case 17.



Case 17.

After treatment. The edge of the lung is well shown on both sides.

Case 18. Female. Aet 23. Housewife. 1₂S.
Admitted to the Johannesburg General Hospital
complaining of vomiting. Her symptoms started
about one year previously with attacks of gastric
pains and vomiting. She had no appetite and lost
a good deal of weight. Her cough had appeared,
and she brought up a little sputum in the morning.
She rested in the Free State for some time, but
latterly her symptoms had got worse. Menstrua-
tion was always irregular. On examination she
was suffering from severe toxæmia, and there was
a well marked involvement of the right lung. A
pneumothorax was commenced on the 12th March 1927,
and a complete collapse was secured. There was a
severe reaction after each refill and X-Ray showed
that the Mediastinum was displaced on each occasion.
It took some time to regulate the amount of air,
and the spacing of the refills to overcome this
trouble. After the treatment had been in progress
for six weeks, it was discovered that she was preg-
nant, a complication she swore she was not aware of.
The pregnancy was immediately terminated, and luckily
without producing any untoward symptoms. From then
on her progress was rapid, and she gave no further

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trouble. No complications followed, and her treatment was stopped in June 1929. She has kept well ever since.

Case 19. Female. Aet 28. Housewife. 1₃S.
Admitted to the Johannesburg General Hospital on the 1st February, 1921, complaining of cough and loss of voice. Her history was that the tuberculosis was first recognised following the birth of a child about three years previously. She had a cough and sputum and lost weight. Under treatment of rest she improved, but about a year ago she became pregnant and following a miscarriage at about the sixth month, all her old symptoms began again in a fulminating manner. There had been a big haemoptysis, and since that there was extreme loss of weight, cough, sputum, night sweats, and finally loss of voice. On examination, she was extremely ill with complete aphonia, and the whole of the left lung was involved in an acute tuberculous broncho-pneumonia evidently spread by the previous haemoptysis. Cavity formation was observed. She was almost moribund, and as a last resort, a pneumothorax was attempted. On the 2nd March 1921 a complete collapse was finally secured much to one's astonishment. The systemic intoxication cleared up in a remarkable and dramatic manner, and within a few months she was apparently completely

restored to health. An effusion developed but did not require to be tapped. She became pregnant during the course of the treatment, but the womb was emptied about the sixth week. No other complications arose. The refills were regularly applied; treatment was eventually terminated in June 1925. She is now well and has never had any further trouble.

Case 20. Male. Aet 26. Engineer. 1₃ S.

Admitted to the Johannesburg Hospital on the 21st December 1926, complaining of cough and marked loss of weight. His symptoms had started about a year previously with extreme lassitude and loss of weight. The cough was not very troublesome but there was a certain amount of sputum in which tubercle bacilli were found. He was originally seen in Durban, and on examination the right lung was found to be extensively involved with tuberculous disease. There were physical signs in the left lung both clinically and on X-Ray examination. He was very toxic, and in spite of complete rest was losing ground very rapidly. A pneumothorax was induced on the 5th January 1926. A very good collapse was secured but at the apex adhesions prevented its completion and unfortunately it was the site of the cavity. In spite of this he did fairly well but if the cavity had been obliterated the results would have been much better. He has stayed fairly well, and all the systemic intoxication disappeared. He was discharged to attend as an out-patient on the 8th April 1927, and his treatment terminated June 1930. He has always been a long,

thin, individual and has not put on very much weight. He is not able to continue his occupation but has been engaged in office work for about a year. He is now free from all symptoms. He had no time to develop any complications, and the left lung improved as the S factor diminished.

Case 21. Aet 22. Female. Typist. L₂S.

Admitted to the Johannesburg Hospital on the 6th March 1925, complaining of cough, sputum, and loss of weight. Her symptoms had started a few months before but as the whole of her family had died of pulmonary tuberculosis, she immediately sought medical attention. On examination, there was only a slight involvement of the left lung, and she was sent to a Sanatorium where she improved to some extent. She was again admitted to hospital on the 12th June 1926, and in view of a very grave family history, a pneumothorax was attempted, but after many attempts, no induction of air could be secured, and she was again discharged to be re-admitted on the 17th October under my care for the treatment of a non-tuberculous skin condition. Once more collapse therapy was attempted and was finally successful after the fifteenth effort. No very great amount of collapse was secured, as the adhesions were very extensive. The collapse was maintained for over a year, but gradually an obliterative pleurisy prevented the pneumothorax being continued. She made no very great improvement in spite of the collapse which was really insufficiently

complete. She gradually went down hill, and died about two years after the cessation of the treatment.

Case 22. Female. Aet 31. Housewife. L₂S.
Admitted to the Johannesburg Hospital on the 4th
August, 1927, complaining of cough and wasting.
Her symptoms started about two and a half years ago
with "colitis" and she had lost weight. Later a
cough appeared, and she was never able to regain
her strength. Rest and fresh air had helped her,
but when seen, she had a fair degree of systemic
intoxication and the left lung was moderately
involved. Clinically the right lung seemed clear,
and X-Ray examination showed a moderate amount of
fibrosis. A pneumothorax was induced on the 15th
August 1927, and a fair degree of collapse was
obtained, but adhesions prevented a complete collapse.
She improved in that her toxic symptoms cleared,
and she was discharged to attend as an out-patient
on the 6th October 1927 and for six months every-
thing went well, but she then developed a cough,
and on examination signs of active disease of the
contra-lateral lung were observed, and on examina-
tion of her sputum which had previously dried up
showed the presence of tubercle bacilli. The
treatment was terminated in November 1928 a year
and three months after induction, and she was put

on complete rest, and again she began to improve and the symptoms lessened. The patient is alive now and quite well, and is able to get about although a long daily rest is observed.

Case 23. Female. Aet 34. Housewife. 1₃S.

Admitted to the Johannesburg Hospital on the 8th September 1924, complaining of cough and loss of weight. She had been ill for about two years with these symptoms following an operation for mastoid disease and had been in the country resting but had gradually gone down hill. On examination she was very ill and both lungs were extensively involved. The right lung showed cavity formation, and the left a moderate amount of disease. She was kept in hospital and improved to some extent, and because of this, and also as she saw the results of other cases, she begged to have artificial pneumothorax induced; collapse was done two months after admission, and she left on the 12th May 1925 to attend as an out-patient. Refills were kept up regularly, but no improvement took place after her discharge from hospital. She steadily lost weight, and the treatment was terminated in August 1925. She died about a year later.

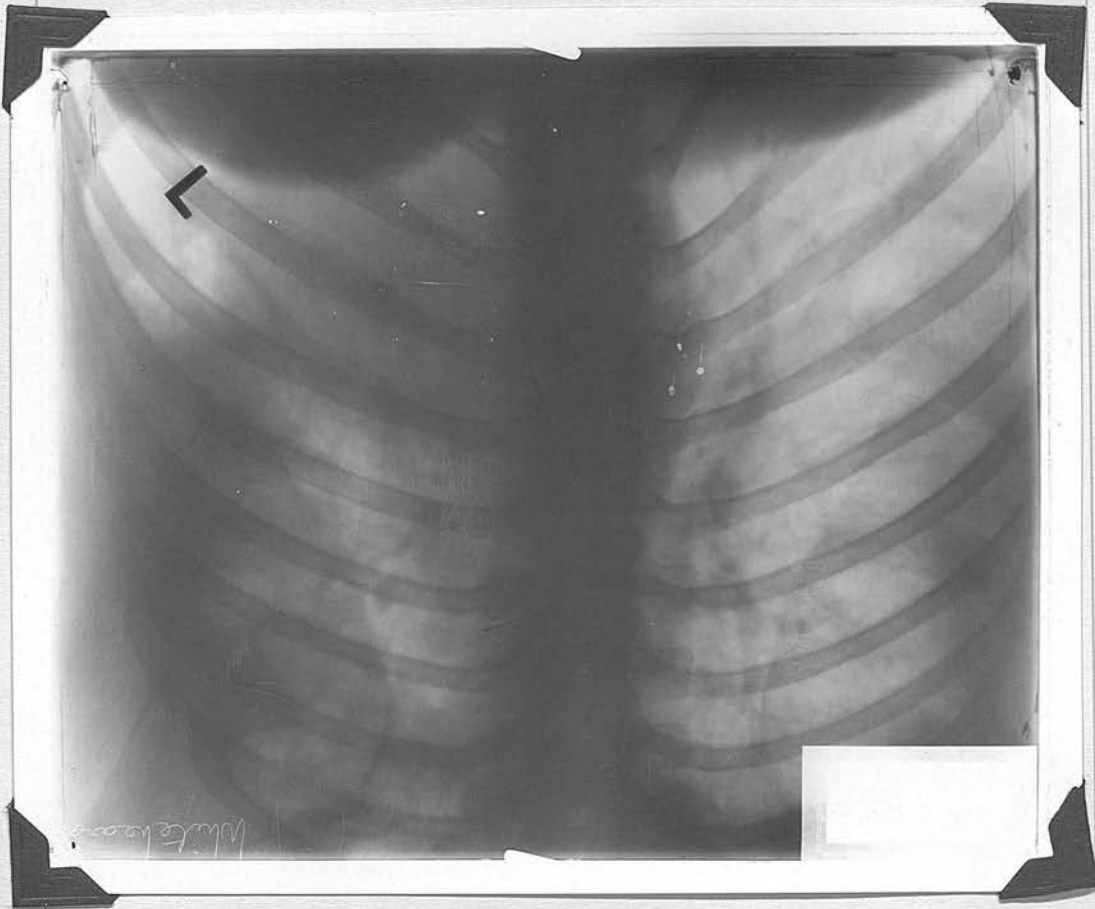
Case 24. Female. Housewife. Abscess of Lung.

She was admitted to the Johannesburg Hospital on the 21st November 1927, complaining of cough, offensive sputum, and of fever. She had had her tonsils removed in Rhodesia five months before admission. Three weeks after their removal she had begun to cough, and her sputum had become extremely offensive. On admission, the patient was suffering from a marked toxæmia, high temperature, and rapid pulse. The breath was most offensive, and the cough was paroxysmal and extremely distressing. The sputum was copious, foul and purulent. Examination showed the left lung extremely dull to percussion with bronchial breathing. The case was diagnosed as abscess of the lung. Burney Yeo's inhaler was used, perchloride of mercury 1/32 grain intravenously was given, and many other forms of treatment were tried. In spite of it all, her condition got worse.

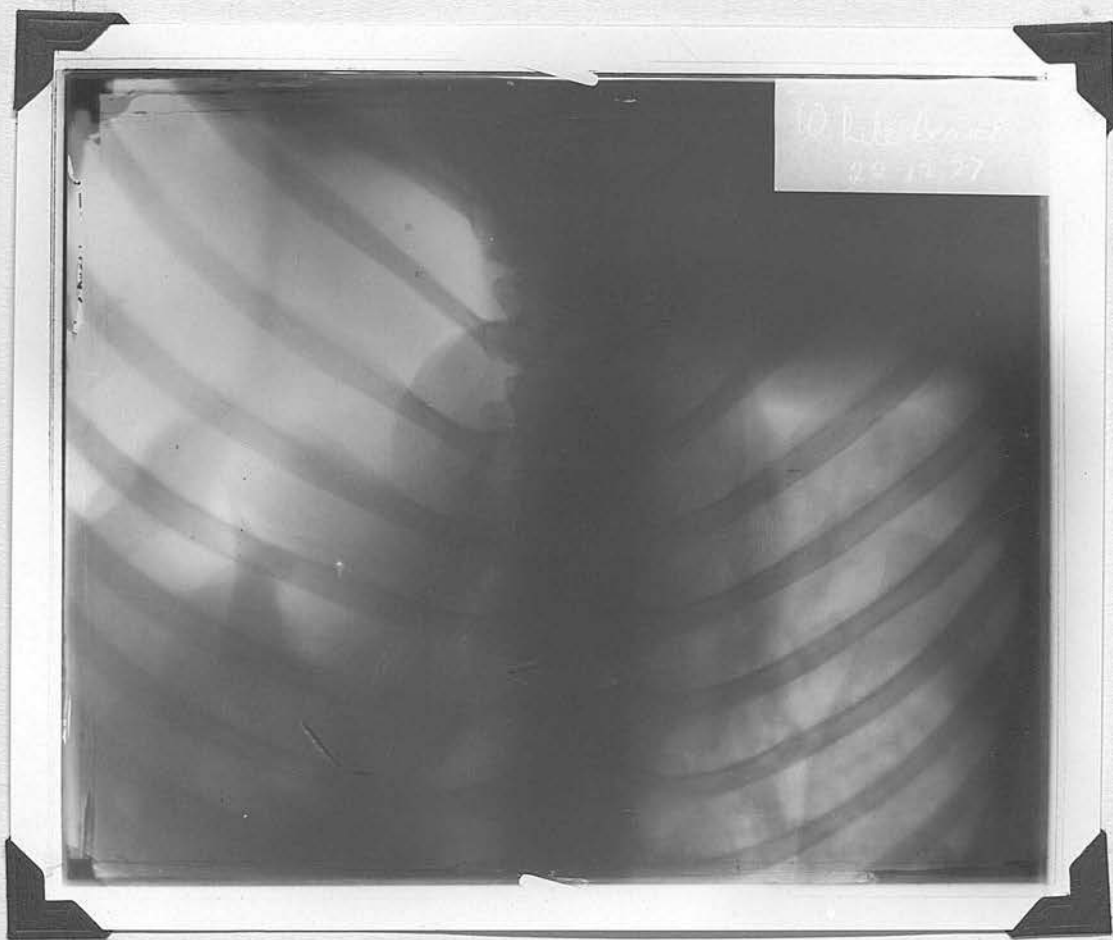
Artificial pneumothorax as a last resort was attempted. One had in view two possibilities (1) that it might be possible to secure a complete cure, but if that were not possible (2) by immobilising the lung, to get some relief of symptoms. A fairly

good collapse was secured, with a certain amount of relief of cough and the sputum came up more easily, but the temperature and pulse remained as before. Unfortunately after three weeks of treatment, the toxæmia increased and an empyema developed. It was explored and tapped and about ten ounces of foul stinking pus was evacuated. Her condition got steadily worse, and she died on the 8th January 1928, four weeks after the institution of the pneumothorax.

X-Ray shows the abscess of the lung before and after collapse. Although a good pneumothorax at the base has been attained the upper lobe is so infiltrated with disease that it will not collapse. It is also held up by adhesions.



Case 24.



Case 24.

After treatment.

Case 25. Aet 31. Male. Merchant. Abscess of lung.

This patient was admitted to the Johannesburg General Hospital on the 5th January 1925, complaining of cough and offensive sputum, loss of weight, and fever.

He had had his tonsils removed on the 21st November 1923, rather over a year before. A few days after their removal he developed a cough, and a foul smelling sputum. The diagnosis of an abscess of the lung was made at the time, and various palliative treatments had been tried. The condition got steadily worse, and it was finally decided to attempt an artificial pneumothorax, as a last resort as life had become unendurable. Three hundred cc's. of air were introduced in the pleural cavity on the 12th January 1925, but in spite of the small amount, a spontaneous pneumothorax occurred following a fit of coughing due to the tearing of an adhesion. This was followed by a pyo-pneumothorax, and foul smelling pus. The pus was evacuated on several occasions, the patient got rapidly worse and he died on the 31st January 1925.

Discussion of Cases.

Selection of Cases for Treatment.

The success or failure of the treatment of pulmonary tuberculosis by means of collapse therapy will depend very largely on the selection of suitable types of cases. It is noticed that many authors classify their cases in terms of the anatomical involvement of the lung. The amount of the systemic disturbance is either not mentioned or only casually commented on. It seems to me as necessary to estimate the systemic intoxication as it is to determine the degree of lung involvement, and to have a classification that will embody both and from this system select the cases not only for artificial pneumothorax therapy but for all methods of treatment.

A number of these classifications have been published from time to time but they are usually unwieldy and involved. Sir Robert Philip's is the one that I have always used.

Scheme of Clinical Classification (Philip).

The so-called Turban-Gerhardt classification which was adopted by the International Conference

on Tuberculosis of Vienna is as follows:-

The three stages of pulmonary tuberculosis recognised under the scheme:-

Stage 1. Disease of slight severity, limited to small areas of one lobe, which, for example, when affecting the apices bilaterally, does not extend beyond the spine of the scapula and the clavicle, or, unilaterally, does not extend below the second rib anteriorly.

Stage 2. Disease of slight severity, more extensive than Stage 1, affecting at most an entire lobe, or of greater severity, extending at most over half a lobe.

Stage 3. Disease of greater extent than just defined, and all cases with considerable cavities.

Such a classification, excellent as it may look on paper, is misleading and insufficient. In actual fact, a case in Stage 3, may really be less serious than a case in Stage 1, and so on. The classification does not differentiate between the various types of illness which anatomically may have more or less the same basis.

The following classification gives approximately just expression both to the amount of anatomical involvement and to the systemic disturbance.

It groups cases more satisfactorily from the clinical standpoint, and affords valuable indications as to prognosis and treatment.

The symbol L represents the local or lung lesion, and the symbol S the systemic disturbance. For convenience the three anatomical stages already referred to are accepted and described as L_1 , L_2 , and L_3 . By the simple device of combining variously capital and small letters, the diagnosis at a given time can be expressed with reasonable accuracy. Thus, in case of a limited involvement of the lung, the various possibilities may be stated as L_1 - a slight process without systemic disturbance, or L_1s - a slight local process with relatively slight systemic disturbance, or L_1S = a slight local process with equivalent systemic disturbance, or l_1S = a slight local process with excessive systemic disturbance. It matters not what amount of local lung involvement exists, whether L_1 , or L_2 , or L_3 , the same principle of classification is available.

Practical experience has shown the value of such a system. It has not merely a value in relation to diagnosis at a given moment, but affords a most serviceable means of recording the changes which occur

from time to time in such cases, whether in the direction of improvement or the reverse.

The following Table shows the scheme of classification and the symbols in use:-

L_1	L_1s	L_1S	l_1S
L_2	L_2s	L_2S	l_2S
L_3	L_3s	L_3S	l_3S

The presence of complications is indicated by the symbol + followed by a reference to the lesion, e.g., $l_3S + \text{ent. tub.}$, indicates a case of extensive lung involvement (vomica formation) and excessive systemic intoxication, along with intestinal tuberculosis.

It seems advisable here to discuss what constitutes systemic disturbance and how it is estimated. One may divide these symptoms into two groups:-

- (1) Those directly due to the local lesion in the Respiratory organs.
- (2) Those due to the toxæmia produced by the specific action of the bacilli and their soluble products in the blood and lymphatic streams.

The symptoms arising from the local effects of the disease are cough and sputum and their character.

The presence or not of tubercle bacilli - Haemoptysis and Pleurisy.

The toxic symptoms are the feeling of malaise and general ill health, temperature, increase of pulse rate, loss of weight, anorexia and such other symptoms as may be attributed to the effects of overdoses of auto tuberculin. The above features should be carefully evaluated in estimating the size of the S.

In addition to the above certain blood examinations are often of value. The simplest and the best is the blood sedimentation rate. It must be remembered that it is used not as a sign of tuberculous disease but as a sign of the degree of activity of the process. It has been used by me for some years in helping to estimate the improvement of cases of artificial pneumo-thorax and I consider that it has a definite value in these cases.

Presence of Tubercle Bacillus.

Koch's bacillus was found in all my cases of artificial pneumo-thorax before induction.

The Matsons (Amer. Review of Tuberculosis, 1924) in a series of six hundred cases found that 70% lost their tubercle bacilli after satisfactory collapse; and 25% after partial collapse, whereas only 15% lost theirs where adherent pleura prevented any collapse at all.

Tubercle bacilli in the sputum are the most definite signs of activity of the tuberculous lung, and although their presence may not indicate treatment by means of collapse, yet their absence definitely contra-indicates its application.

Early disease and cases of closed tuberculosis are particularly suitable to ordinary methods of treatment and it must be exceptional to have to subject these types to a prolonged and tedious treatment.

If this classification is carefully followed out the choice of cases becomes relatively definite. Column 1 cases are at once eliminated as they require no other treatment than a careful supervision. It is to this stage that one hopes and aims to get all cases of artificial pneumothorax. The type of case

described in the next column is also unsuitable for collapse therapy as they do well in a sanatorium but they have to be carefully watched and if any signs of their merging into the next group appear then collapse therapy should be exhibited. In South Africa ideal treatment is not always available and column 2 cases must be under constant medical supervision for fear that disease will advance to a stage where treatment of any kind will be useless.

Column 3 gives a number of suitable cases for artificial pneumothorax, although sanatorium treatment is also very advisable in cases of this group. When both lungs are infected with disease, care and experience are required to select possible cases from this group for collapse therapy. No hard and fast rule can be laid down for this selection but it is advisable not to leave too much to the X-ray and by repeated clinical examinations decide this very difficult choice not only in this group but also in cases from Column 4. These cases are very often too advanced for any treatment but as will be shown it is from this group that most of ones cases have come.

To summarise the types suitable for either

sanatorium or collapse therapy one may say that Column 1 requires no treatment, Columns 2 and 3 broadly speaking are eminently suitable for sanatorium treatment but if they do not respond then it is from these cases and those of group 4 that cases are selected for collapse therapy - always remembering that the disease must be as nearly unilateral as possible.

In my cases only one L_1S was done and that because temperamentally he was unsuitable for sanatorium treatment, eight fell into L_2S ; seven L_2S were done and seven L_3S cases. In other words nine fell into column 3 and fourteen into column 4.

The broad indications for artificial pneumothorax treatment have been carefully classified but certain reservations must be laid down and the temperament of the patient must be closely observed before advocating collapse of the lung. Case 6 in my series was not a suitable case, she herself was too young and her parents were not of the type to understand or realise the importance of the treatment in spite of repeated warnings. She did not present herself regularly for her refills - the lung kept on partially expanding and an optimum pressure could not be kept up and finally the contra-lateral lung broke

down. In Case 4 on the other hand, this patient was quite unfitted mentally to undergo a long course of sanatorium treatment and yet he attended regularly for his refills and has done very well.

Tuberculous Diathesis. Case 21 seemed in all ways a suitable case except that the rest of her family had, however, all succumbed to this disease. A fair degree of collapse was secured but she failed in every respect to respond to the treatment.

Extreme bi-lateral disease should never be attempted for unilateral collapse. Case 23, one of my earlier cases had both lungs very severely involved and one foolishly hoped that by collapsing the worse lung life would be prolonged. The other lung was definitely active and at no time did the patient really improve and later there was a steady increase of the toxæmia and finally death occurred. On the other hand as in Case 8 what appeared at first sight to be an advanced bilateral case after observation and a certain amount of rest did quite fairly well with an artificial pneumothorax and as can be seen from her X-ray the better lung actually seemed to clear up under the treatment.

One must again emphasize that careful clinical

observations are the best method of determining the suitability or otherwise for collapse therapy.

Progressive disease of the lung is an indication for the immediate cessation of the artificial pneumothorax. Case 22 appeared to be a very suitable case, the other lung was clear both clinically and radiologically and for the first few months her progress was favourable but at the end of six months treatment, it was found that the other lung had become diseased. Treatment was at once terminated and she once more began to improve and is still alive. The treated lung has become fibrotic and the other lung did not progress after the strain on it had been relieved.

Palliative measures. Collapse therapy is justified in cases of recurrent and profuse haemoptysis. Case 1 had severe haemoptysis. The disease was bilateral and extensive as can be seen on the X-ray. There was a cavity at the left apex, the side from which the haemorrhage was taking place was definitely ascertained. A collapse was secured and the haemorrhage ceased. Treatment was not kept up for long on account of the condition of the other lung, but no further haemorrhages has occurred. One was lucky as the difficulties are the presence of adhesions in these

cases which are usually of old standing and also they are usually bilaterally affected and the site of the haemorrhage is not easily determined.

Bilateral collapse of the lung - two procedures are described:-

- (1) Simultaneous partial bilateral pneumothorax.
- (2) Collapse of one lung first and after allowing it to expand collapse the other lung.

The results are as one can readily understand of a most unsatisfactory nature. They are all cases of extensive disease and the prognosis even before the collapse is extremely grave. Occasionally the acute progress of the disease has been slowed down and that is the best that can be hoped for. The results will vary with the severity of the disease.

The results of the case (see Case 17) reported by me are in many ways similar to the results obtained by others, the experience gained in this case was, that life seemed to have been definitely prolonged. This condition was so bad on admission to hospital that it appeared as if he would have died within a month or two, whereas with the induction of an artificial pneumothorax he lived for about a year. The symptoms and the intoxication were relieved although not completely and it seems as if better

results would be obtained in cases that are not too acute. Against a simultaneous bilateral collapse is that it is very unlikely to be curative; it is a palliative or life prolonging measure.

The time taken up and the careful watching that is necessary in these cases is very great and is a deterrent in a hospital practice. I think that three or four of these cases would be as many as any one could handle.

An X-ray in the appendix shows the amount of disease of the lungs and a second film records the degree of collapse of both lungs.

Below is appended a chart of the amount of air induced and the frequency of the refills.

They demonstrate (1) the amount of collapse that can be borne with some degree of comfort.

(2) The unceasing effort on the part of the operator.

Case 17. Age 21 years. Pneumothorax. 17/9/27.

<u>Date.</u>	<u>Right</u>	<u>Left</u>	<u>Date.</u>	<u>Right</u>	<u>Left</u>
	<u>Chest.</u>	<u>Chest.</u>		<u>Chest.</u>	<u>Chest.</u>
Nov. 17th.	300 c.c.		May 29th.		600 c.c.
" 18th.	420 c.c.		June 20th.		500 c.c.
" 25th.		300 c.c.	Aug. 7th.		600 c.c.
" 26th.		150 c.c.	Aug. 10th.	600 c.c.	
" 29th.		150 c.c.	Aug. 17th.	420 c.c.	
Dec. 1st.	250 c.c.		Aug. 30th.		500 c.c.
" 5th.		350 c.c.			
" 7th.		350 c.c.			
" 9th.	450 c.c.				
" 10th.		500 c.c.			
" 12th.	620 c.c.				
" 14th.		550 c.c.			
" 21st.		600 c.c.			
" 24th.	600 c.c.				
" 27th.		350 c.c.			
" 29th.	650 c.c.				
" 30th.		60 c.c.			
Jan. 6th.		300 c.c.			
" 12th.	600 c.c.				
" 16th.		270 c.c.			
" 25th.	540 c.c.				
Feb. 14th.		450 c.c.			
" 28th.		730 c.c.			
Mar. 5th.	250 c.c.				
" 19th.		500 c.c.			
" 23rd.	400 c.c.				
" 31st.		650 c.c.			
Apr. 11th.		600 c.c.			
" 20th.		450 c.c.			
" 23rd.	400 c.c.				
May 14th.		1,100 c.c.			

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To summarise simultaneous collapse of both lungs one may say that it does seem possible to select cases from time to time in which life may be prolonged.

Abscess of the lung. Is there any indication for the exhibition of artificial pneumothorax in this condition? Two cases (Cases 24 and 25) were done by me - both ended fatally. It was a foregone conclusion that they were both doing badly but all that the collapse did was to hasten the fatal termination and that is hardly a justification for any treatment.

Beaumont & Dodds (Recent advances in Medicine, page 289, 1929) state that a brilliant cure is especially likely to occur in early cases before adhesions have formed. This applies particularly to those cases resulting from the inhalation of some septic material as may occur after operations upon the throat. They say that even in long standing cases a determined attempt should be made to establish pulmonary collapse.

Both of my cases occurred following a tonsillectomy, one of long and the other of short duration.

Alexander & Buckingham (Journal of American Med. Assoc. Vol. 95, No.20, Nov. 15th 1930, p. 1480) give a wiser criticism. They say a few cases of

abscess, perhaps complicated by dangerous haemoptysis that persist, may be treated by artificial pneumothorax and the results are occasionally astonishingly good, if used at all it should be limited to the early stages of abscess before adhesions form which are liable to tear and produce an empyema. In my two cases this is exactly what occurred; in the one an adhesion tore across and produced a spontaneous pneumothorax and an empyema followed and in the other case although no adhesions were torn a stinking empyema formed seemingly from a diapidesis of the organisms.

To summarise, one may say that the only indication for an artificial pneumothorax in abscess of the lung is as a temporary life saving resort in cases where secondary haemorrhages are dangerously profuse.

X-Ray. The importance of X-ray examination in the decision as to the suitability or not of cases for artificial pneumothorax treatment must not be under estimated but on the other hand it is unwise to leave too much to Radiological methods. For example if the one film in Case 8 is examined it will be seen that both lungs are so extensively in-

volved that it would appear to be too advanced a case for collapse therapy but when one looks at the second picture taken six months after induction of a pneumothorax of the right side, it shows that the left lung has actually improved under the treatment. X-rays are good servants but bad masters.

Screening of the chest is, however, the only method of telling precisely the extent of the collapse and whether or not adhesions are present, it also helps to decide the amounts of air required and the frequency of the refills, and no other method will tell the operator if small quantities of effusion have formed. One may say that it is inadvisable to undertake this treatment unless an X-ray and screening plant are available.

Results of treatment - In attempting to assess the value of treatment by means of artificial pneumothorax many difficulties are met with. No case of pulmonary tuberculosis in a series is comparable one with another. The cases did not all finish treatment at the same time and home conditions have not always been ideal. Economic conditions have perhaps made it necessary for some to start work earlier than was advisable and these have not finished treatment long enough to be sure that they will not break down at some future time and yet they must be classified as excellent results. It must also be remembered that all these cases were unsuitable for any other form of treatment; in other words rather unfair material to use to illustrate as results of a special method of treatment.

In my series there were twenty two cases of unilateral collapse of the lung, one case of simultaneous bilateral collapse. Two cases were done for suppurative disease of the lung.

I have classified the results into three grades:-

- (1) Fit:- To signify that they are free from all symptoms - the males are all able to work and also those females that are not housewives.

- (2) Improved:- Include those cases who still have symptoms but where the systemic disturbance was considerably diminished for varying periods.
- (3) Failures:- Include those cases which either terminated fatally or when treatment was stopped because the other lung became affected.

The unilateral cases fell in the following groups:-

<u>Group.</u>	L_1S	L_2S	l_2S	l_3S
Number of Cases	1	8	7	6

The other three cases have been previously dealt with. The l_3S group results were one fit, four improved and one failure. In view of the fact that they were such extremely bad cases the results were striking although these results could not be expected to be as dramatic in cases with cavities, as those with lesser degrees of involvement. Case 19 is very well five years after the termination of her treatment so that occasionally a brilliant cure may be effected. A complete collapse was obtained demonstrating that the greater the collapse the better the final result. Case 13 was acutely ill and could not have been expected to live any length of time, there was bilateral disease of the lungs (vide X-ray), and yet collapse of the worse lung held up this rapid

downfall and has given him back a fair degree of health, although he is not well he is able to do a little light work. The other lung cleared up gradually. His results would have been better if adhesions had not prevented a full collapse (vide X-ray). He is alive one and a half years after the cessation of treatment.

Case 1 had recurrent haemorrhages and the artificial pneumothorax was done as a palliative measure. The toxaemia was intense and with the associated loss of blood no permanent result was expected and yet he has improved. The disease in the other lung has fibrosed. He is able to get about and is alive a year after treatment was stopped, although the collapse was terminated after fourteen months on account of his bronchitis.

Cases 8 and 20 were both very acutely ill and their outlook exceedingly grave. Both cases had cavities in the lung (vide X-rays of Case 8). They are not cured but they are alive and are not bed-ridden; Case 8 three years and Case 20 one year after the termination of treatment.

Neither of them are able to carry on at their occupations and one cannot say what their final out-

look will be.

Case 23 was one of extensive bilateral disease. This case has been previously discussed. It should never have been done, one cannot expect to have a series of unadulterated successes and experience does help one to avoid cases that are obviously unsuitable.

The results of this group when tabulated are not striking but the clinical improvement was undoubted. It has to be remembered that they were unsuitable for any other method of treatment. They were very ill and their expectation of life was short. Five of them are alive and comfortable in that their systemic disturbance is diminished and they are able to be up and about. A large number of this type were selected but in many of them adherent pleura prevented any collapse at all. This was most disappointing but not to be wondered at considering the degree of lung involvement and the duration of the disease. In the only case which had no adhesions and where a complete collapse was secured a brilliant result was achieved.

The next group consists of seven 1_2S cases and it was from them that the best results were obtained

and the explanation seems to be that the disease was unilateral in all these cases and that the degree of collapse obtained was either complete or else the extent of the adhesions did not prevent pneumothorax producing absolute immobility of the lung. All this group were extremely ill before induction of the pneumothorax and it was remarkable how rapidly the systemic disturbance cleared up after the collapse was secured. It was due to the freedom of the contra-lateral lung from disease and it was also for the same reason that their stay in hospital was considerably shorter than in those cases where both lungs were affected.

Empyema. Case 3 developed a purulent effusion during the course of treatment and gave a considerable amount of anxiety before the empyema finally subsided. It was tapped and the pus replaced by air on several occasions. The risks were that a sinus would develop along the track of the needle but luckily this did not happen although it occurred in five of Burrell's cases (Recent Advances of pulmonary tuberculosis, 1929, p. 202).

In the majority of cases of these tuberculous empyemata the results are exceedingly grave and unless

they clear up with the above treatment the only hope of saving their lives is to do an oleothorax. The results according to Morriston Davies (Personal communication) are excellent. The liquid used by him is a 5% solution of Gomenol in olive oil. There is a severe reaction in spite of reports to the contrary and only a few c.c's should be injected at the first attempt so as to estimate the sensitivity of the pleura. The technique is simple - as much pus as possible is removed and then 5 c.c's of the oil is put into the pleural space; about ten days afterwards the pus is again tapped and if no reaction occurs after the first injection 10 - 15 c.c's of oil are given and gradually at about ten days interval the oil is injected and finally in a successful case completely replaces the air and also the pus which has ceased to form.

Oleothorax can also be used to replace a pneumothorax in those cases where an obliterative pleurisy is producing its premature cessation.

Pregnancy. Case 18 was found to be in the third month of pregnancy. This discovery was made about two weeks after the induction of the pneumothorax. It did not seem advisable to allow the

pregnancy to continue and it was terminated. Case 19 also became pregnant during the course of treatment and in her case the womb was emptied at about the sixth week of pregnancy.

Burrell (Recent advances of Pulmonary Tuberculosis, page 202) states that in a series of 500 cases, six cases of childbirth occurred during their treatment, five suffered no ill effects but in one case the untreated lung flared up. Riviere (Pneumothorax treatment, page 120) remarks that a pregnancy which has occurred during the collapse treatment has as a rule to be terminated as soon as it is diagnosed.

This latter view seems to be the more reasonable view to take and it is the procedure that I would always advise.

Cases 14 & 19 illustrate the great strain that pregnancy and parturition put upon a tuberculous mother, as in both cases their symptoms began a short while after the birth of a child.

Diabetes. Case 2 was a very severe case of diabetes. His history is given in the appendix. The results were extremely good and he is completely restored to health.

Although the literature is full of the complicating effects of diabetes and pulmonary tuberculosis and the devastating effects that these two diseases have in combination with one another, yet no reports were obtainable about the effects of artificial pneumothorax, upon these associated diseases; except that Young (Lancet, March 22/24, page 582), classes diabetes as a contra-indication.

The fact that only one case has been done by me does not warrant my expressing an opinion on the subject, but it is suggestive that there is scope for this treatment in unilateral cases of pulmonary tuberculosis with a concurrent hyperglycaemia. It has always been known that sepsis acute or chronic is a grave complicating factor of diabetes and that when the sepsis is relieved a vast improvement in the sugar content of the blood is found. The action of the pneumothorax treatment is the relief of the tubercular toxæmia and the dramatic effect achieved in this case will encourage me to apply this treatment as suitable cases are met with.

L₂S cases. There were eight cases in this group and of these five are fit and three were failures. The failures were due to various causes and

illustrate the pitfalls that await even the most careful advocate of artificial pneumothorax treatment.

Case 6 was the one previously described who attended most irregularly and it was this want of co-operation in the treatment that was responsible for this failure. Case 21 had a bad family history although the collapse was not as complete as one would have wished, one feels it was the former cause that was the factor in her rapid down-hill course.

Case 22 developed a progressive disease of the contra-lateral lung; she appeared to have been a most suitable case, the other lung showed no evidence of disease either clinically or radiologically before induction.

The five successful cases are all fit and it is from this group that one would expect a high percentage of good results.

Tuberculous Laryngitis. Case 11 had a definite involvement of the larynx and the same complication was met with in Case 19. It was remarkable how rapidly this condition cleared up after the collapse was induced and at no time since then has there been any return of the symptoms.

11S group consists of only one case; he has done very well and no complications of any importance arose except a:-

Pleural Effusion. This complication occurred in a number of cases and has been discussed fully on the chapter on complications. Its development does not affect the chances of the patient's recovery.

Age. The average age was twenty four years, the youngest was sixteen and the eldest forty-nine. Analysis of the results according to age are not conclusive; actually the oldest, Case 2 did well and the youngest, Case 6 did badly owing to the irregularity of her attendance for refills and suggesting that younger cases more particularly should be impressed with the importance of regular refills.

Sex. Twelve were males and thirteen were females and from the examination of the results it does not seem that sex has any bearing upon the results.

Duration of symptoms before induction averaged about one and a half years, the longest was five years and the shortest three months. Although very careful histories were taken in these cases it is always

difficult to know when the disease became active and often it progresses in the lung for some time before the patient becomes aware of it; after careful examination of the cases they definitely suggest that a more complete collapse was secured and that a better functional result was obtained in those cases whose symptoms were of relatively short duration.

Rest. The average stay in hospital was three months and this seems a long time for hospital treatment. It is important to keep patients at rest until the systemic intoxication has completely disappeared. The patient should be apyrexial not only at rest but also after a fair amount of exercise and it is advisable to build up their powers of resistance and allow as much healing to occur as is possible before discharge from hospital as very often there is not the same care taken nor the maintenance of that discipline which is so essential to cure. A certain number of cases may have to be discharged earlier, i.e., social or economical reasons may make it necessary before they are satisfactorily convalescent.

The ideal method seems to me to combine an artificial pneumothorax with sanatorium treatment,

in South Africa this is not always available but luckily we have in the Johannesburg General Hospital wards with wide verandahs that serve the purpose very well. The only trouble in this arrangement is that the daily cost per bed at a general hospital is a good deal higher than that of a bed in a sanatorium and the hospital management are often unsympathetic about these patients long stay and in the case of paying patients it is often difficult for them to pay these fees.

Amount of collapse. There is no doubt that the greater the collapse secured the better the result and in my cases there was only one failure in the completely collapsed cases, whereas in the incomplete cases no such result was secured, a number have done well but it was easily seen that the smaller the extent of the collapse the less the clinical improvement.

The completely collapsed cases are all very well and where it is necessary are working, many of them running big businesses and supporting families. They are able to play golf or take long walks. A number of the cases where only a partial collapse of the lung was secured are also able to lead active

and useful lives but many of them are unable to do much, perhaps a little light work but very often are only able to take short walks. The results achieved even in these cases justify the treatment, although they are not well they are better than they were before the pneumothorax was started.

Unilateral disease. Practically every case of unilateral disease did very well and the degree of involvement of the lung did not seem to matter, if it were only a matter of securing statistics for this treatment these are the ideal cases for collapse therapy the only bar to success being the possible presence of adhesions.

Cavity formation. The results of cases with cavity formation were not very good but they were, with one exception only, all cases with some degree of involvement of the other lung and most of them were cases of long standing. A number did improve but only one dramatic success occurred. This was Case 19 and in her case only the left lung was affected and no adhesions were encountered.

Analysis of Results.

So far, one has shown what results can be obtained in certain types of pulmonary tuberculosis and the effect that various complications have upon these results. It has also been shown that many associated conditions respond to this form of treatment.

In this analysis it must always be remembered that the cases selected were, prior to the start of this treatment, all doing badly. Therefore the results are not comparable with, say, the results of sanatorium treatment.

The cases are the first twenty-five consecutive cases done who have all had their treatment completed for at least one year. A larger number of cases could have been given, but they did not fulfil the above conditions.

It should be added that all the above cases were Europeans. Natives are not suitable for this type of treatment, owing to their general lack of intelligence.

Fourteen cases are alive and well, two are dead and six are alive but the disease is not completely arrested.

A table is appended showing the groups according to Philip's Classification from which these were taken.

Analysis of Results.

<u>Classification.</u>	<u>Total.</u>	<u>Fit.</u>	<u>Improved.</u>	<u>Dead.</u>
L ₁ S	1	1	-	-
L ₂ S	8	5	2	1
l ₂ S	7	7	-	-
l ₃ S	6	1	4	1

Of the fourteen who are alive and well a table is given showing the number of years since the termination of treatment.

<u>Fit Cases.</u>	<u>Year of Termination.</u>
1	1925
2	1926
1	1927
4	1928
5	1929
1	1930

Bennett in Recent Advances in Pulmonary Tuberculosis, gives statistics of 500 cases, and the Matsons in Tubercle 1925 give the results of 492 cases.

It is extremely difficult to analyse their results as their classification of cases chosen for this treatment is far from clear. They classify their cases in terms of the pathological type of

disease and do not mention systemic disturbance.

It seems a matter of great importance to have some generally accepted form of classification of tuberculosis.

Summary and Conclusions.

Treatment by means of artificial pneumothorax is an addition to existing methods and the best results are obtained when it is used in association with these.

It should, with few exceptions only, be used when sanatorium treatment has failed.

The need of an early decision is, however, necessary as delay allows disease to spread and then no treatment is of any avail.

The selection of cases for treatment is most important, and it is necessary to have a classification which will embody both the extent of the local lesion and also estimate the degree of systemic intoxication.

Sir R. W. Philip's classification is the simplest and clearest and has been used throughout this work. This classification makes the selection fairly simple and it also allows the results to be correctly judged.

Certain points must be borne in mind in selecting cases; the principal are:-

Tubercle bacilli in the sputum is the most important indication and their absence constitutes

the greatest contra-indication.

X-Rays are a help but the final selection is made by clinical examination. X-Rays are a good servant but a bad master.

The best results are obtained in cases which are clinically unilateral.

Artificial pneumothorax treatment is unnecessary in early cases and useless in advanced cases except in a very limited number, unless it is possible to produce a bilateral collapse of the lung.

Bilateral collapse is not curative but may prolong life. Collapse therapy may be used as a palliative measure in cases of dangerous haemoptysis.

The greater the experience of the operator, the fewer the contra-indications.

Artificial Pneumothorax for the treatment of suppurative diseases of the lung is usually contra-indicated.

The apparatus is very simple and the technique is easily mastered.

Adhesions are the bugbear of the operator, often preventing any collapse and at other times allowing only such a small one to be secured that very indifferent results are obtained. The more complete

the collapse the better the result.

An optimum pressure must be maintained throughout the treatment. Inexperienced assistants are liable to put in excessive amounts of air.

The treatment is long and tedious both for the patient and the doctor and it is inadvisable to start a case which is temperamentally incapable of keeping up treatment for two to five years.

Screening of the chest at regular intervals is essential and the treatment should not be undertaken if X-rays are not available.

The commonest complication of treatment is a pleural effusion, but this does not affect the patient's chances of recovery. Other complications are not common.

Accidents during treatment are rare and very often due to carelessness of the operator.

Artificial Pneumothorax treatment is a great advance in the treatment of pulmonary tuberculosis and should be used by every phthisiologist.

Statistical results are not easily classified. Results depend on a number of factors, and the selection of cases, the degree of collapse, and the skill and knowledge of the operator.

Nothing is more gratifying than to obtain healing in cases that have failed to respond to other methods of treatment.

Bibliography.

- Alexander and Buckingham. Journal Amer. Med. Assoc. Vol. 95. No.20. Nov. 15th 1930.
- Beaumont. Proc. Roy. Soc. Med. 1924.
- Beaumont and Dodds. Recent Advances in Medicine. 1929.
- Burrell. Recent Advances in Pulmonary Tuberculosis. 1929. Tubercle 1925. vi. B.M.J. 1924. i.
- Chandler. Tubercle xi. 1930. Personal communication.
- Davies Morriston - Personal communication.
- Gardner Leroy. American Review of Tuberculosis. 1924 -1925. X.
- Gardner, Petroff and Baldwin - Bacteriology, Pathology and Laboratory Diagnosis of Tuberculosis. 1927.
- Hilton. St. Bartholomew's Hospital Reports. Vol. LXI. 1928.
- Lillingstone. Practitioner. 1913.
- Matson and Bissaillon. Tubercle. 1925. vii.
- Parry Morgan. Lancet. 1913. ii. Quarterly Journal of Medicine 1917.
- Philip, Sir. R. W. Scheme of Classification.
- Riviere. Pneumothorax and Surgical Treatment of Pulmonary Tuberculosis. 1927.
- Young. Lancet. March 22nd 1924.
- Wingfield and Wilson. Lancet 26th 1924.
- Also paper by the author in the Journal Med. Assoc. S. Africa. Sept. 1928.